DOCUMENT No. 26.

FIRST ANNUAL REPORT

ON THE

GEOLOGICAL SURVEY

OF THE

STATE OF OHIO.

BY W. W. MATHER,

PRINCIPAL GEOLOGIST, AND THE SEVERAL ASSISTANTS.

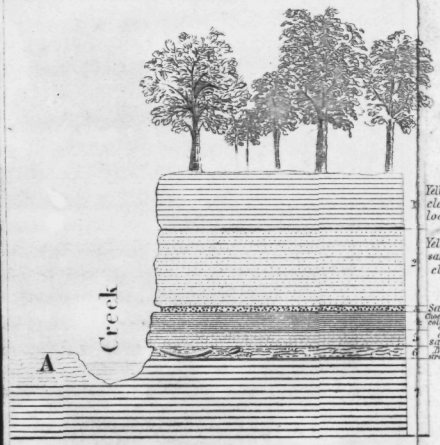
EXECUTIVE OFFICE, OHIO,
Columbus, January 17, 1838.

To the General Assembly of the State of Ohio:

I have received, and herewith transmit to you, the reports of W. W. MATHER, and his ASSISTANTS, composing the Geological Corps of this State, numbered one to seven, inclusive.

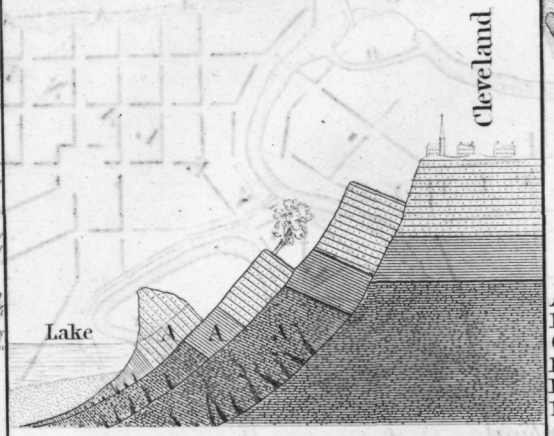
JOSEPH VANCE.

Fig. 3



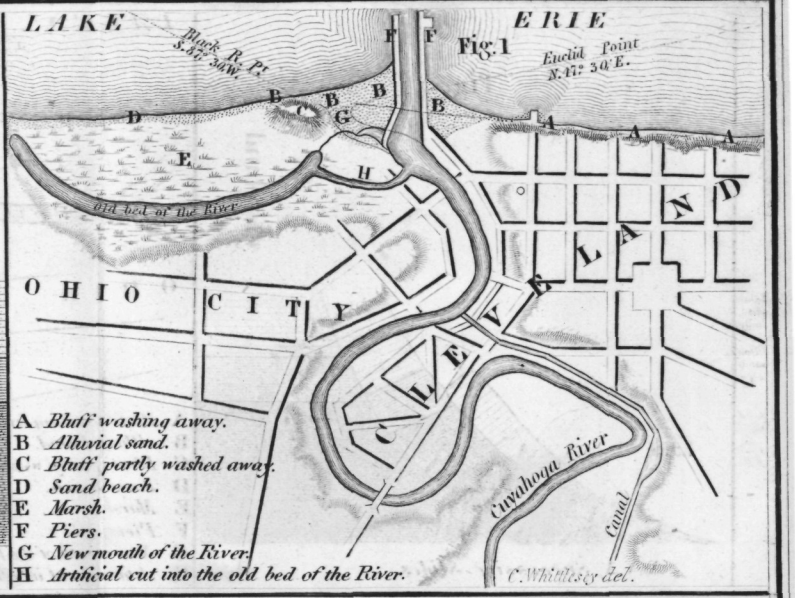
A. *Alluvion*

Fig. 2



A.A.A. *Successive Slides*

Fig. 1

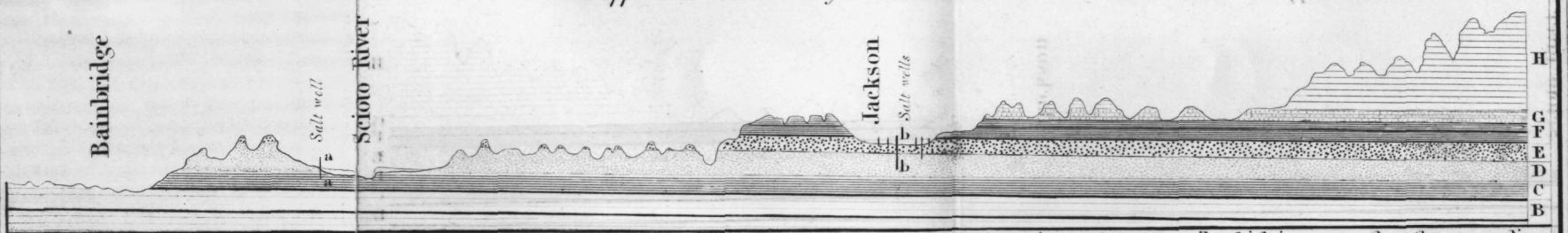


A *Bluff washing away.*
B *Alluvial sand.*
C *Bluff partly washed away.*
D *Sand beach.*
E *Marsh.*
F *Piers.*
G *New mouth of the River.*
H *Artificial cut into the old bed of the River.*

C. Whittlesey del.

Fig. 4

GEOLOGICAL SECTION to illustrate the superposition of the rocks of the S. part of Ohio, between the great limestone deposite & the upper part of the coal series, as determined
by
C. BRIGGS JR. assisted by J.W. FOSTER.
The upper coal series G & H *by* DR. S.P. HILDRETH



Strata indicated in groups, without reference to relative thickness. Section 65 Miles. Dip on the section 30 feet to the mile, which is greater than the mean dip.

A.
B. *Great limestone deposit.*
C. *Slaty argillaceous rock containing pyrites, and nodules of septaria & argillo ferruginous limestone.*
D. *Waverly sandstone series.*
E. *Conglomerate.*
F. *Lower coal series.*
G. *Calcareosilicious rock.*
H. *Upper coal series.*

W.W. Mather del.

Woolliter & Munson Lith.

No. 1.

FIRST ANNUAL REPORT

ON THE

GEOLOGICAL SURVEY OF OHIO.

BY W. W. MATHER, Principal Geologist.

To his Excellency, JOSEPH VANCE:

SIR: In obedience to your directions, and under the authority of an act of the Legislature, a Geological Survey of the State has been commenced. The early part of the season was devoted to making a geological reconnoissance of the eastern section of the State, with a view to study the great outlines of its geology, and to acquire a knowledge of the general resources of the country in useful minerals, so as to direct the detailed examinations in such a manner, as to be productive of the greatest utility to the great body of the people. The mineral wealth of Ohio is greater than my most sanguine anticipations had led me to expect. Most countries depend, for their mineral wealth, on mountainous or barren regions; but Ohio, in common with some other parts of the United States, is blessed, not only with a fruitful soil, but also with inexhaustible subterranean riches.

In your late annual Message, you have remarked upon the coal and salt deposits, and urged the necessity of new lines of intercommunication to facilitate the transport of our mineral products.

The working of the coal mines of Ohio, which may be considered inexhaustible, must become one of the most productive branches of industry in the State.*

From the reconnoissance of the past season, it is estimated that about 12,000 square miles of the State, are undoubtedly underlain by coal, and 5,000, by workable beds of this valuable mineral. In many places, several successive beds of the coal are superposed one over the other, with sand-stone, iron ore, shale and lime-stone intervening. The coal beds are favorably situated for working, as they are found in the hills and ravines where they can be drained with little expense, and without deep shafts and expensive machinery, like those of Europe, or some parts of our own country. It is impossible, with the data as yet ascertained, to estimate the amount of workable beds; but probably a mean thickness of 6 feet of coal capable of exploration over 5,000 square miles, is a moderate estimate of our resources in this combustible. Our citizens are not yet aware of the prospective

*The coal formation constitutes the principal mass of the S. E. section of the State, and the economical geology of a portion of this, lying between the waters of the Scioto and Great Hockhocking, only, will be discussed in detail. Prof. Briggs was directed to prosecute this work, and the details will be found in his report.

value of coal lands; and it is, perhaps, only by setting their practical utility before them, that they will appreciate the importance of this mineral on their estates.

It requires a man of the greatest muscular power, to raise 3,750 pounds one foot per minute, through a time of ten hours per day, which is equal to 2,250,000 pounds, or more than 1,000 tons; but one bushel of coal applied to steam machinery, produces a power equal to that of lifting 60,000,000 to 90,000,000 pounds one foot high.* Taking the lower power of 60,000,000 of pounds, which is equal to more than 26,785 tons, the power produced by the combustion of one bushel of coal in the present improved steam machinery, is equal to the greatest muscular force of 26 men for a day of 10 hours' labor. Coal is worth, in Ohio, from 4 to 18 cents per bushel; and a man's daily labor, from 50 cents to $1,50.

A furnace, consuming 700 bushels of charcoal per day, for 200 days in the year, will require from 2,000 to 5,000 acres of woodland to keep it constantly supplied. Coal land, with only 1 yard in depth of coal, would supply the same furnace at the rate of one acre per year, while the coal land would still remain in a state fit for cultivation.

When we reflect upon the quantity of wild land necessary to keep one furnace in operation, where charcoal is employed, we can easily conceive how great an advantage it will be, to be able to use a combustible which is stored below the surface of the earth in inexhaustible quantities, while the soil above, may be covered with abundant harvests, and with thriving villages, towns and manufactories.

The annual consumption of coal in England is from 14,000,000 to 15,000,000 of tons. If wood were used in lieu of this, it would be necessary to keep an area of land in a wild state, nearly 200 miles square. This area is greater than that of England and Wales, in which this consumption takes place. The coal deposits of England, therefore, are indispensable to enable her to support so dense a population, and maintain her commercial prosperity and manufacturing interests. Every square mile, containing two yards in thickness of workable coal, will yield about 6,000,000 tons, which is an abundant annual supply of fuel for all the people of this State, both for domestic and manufacturing purposes; and, if we allow double this amount for prospective consumption, in consequence of increased population and manufactures, we have coal within a moderate depth, sufficient for consumption during 2,500 years. If we consider the value of coal as a means of *motive power* in propelling machinery, each acre, of the 5,000 square miles of coal, contains stored and ready for use, a power equal to that of 192 men for 100 years, working 10 hours per day. Allowing a profit of only 25 cents on each cubic yard of coal, an acre would yield a profit of more than $2,000 where a depth of 6 feet is worked.

These facts will, it is hoped, lead our citizens to appreciate the vast

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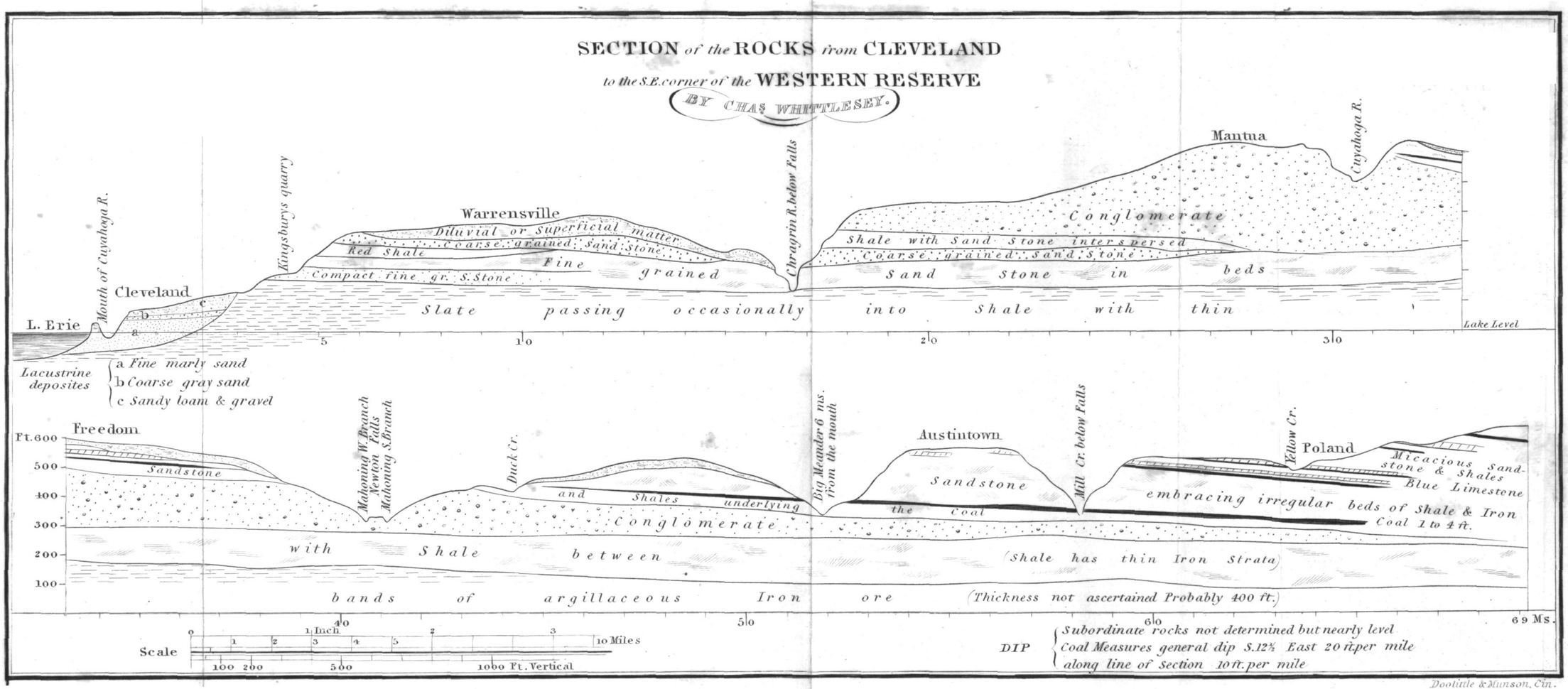
* Vide the duty of the Cornish steam engines in Taylor's Records of Mining.

SECTION of the ROCKS from CLEVELAND

to the S.E. corner of the WESTERN RESERVE

BY CHAS WHITTLESEY.



Doolittle & Munson, Cin.

mineral resources in this valuable combustible, with which our territory, through Infinite Wisdom, is so bounteously supplied.

Iron Ore.

The iron ores of Ohio are abundant, and are beginning to be extensively worked. The extent of country underlain by accessible beds of iron ore, is very great. The limits are not yet ascertained, with sufficient accuracy to define them; but the beds crop out on a belt of country, extending from near the mouth of the Scioto, in a N. NE. direction, nearly across the State. The beds, in some places, are too thin to be wrought with profit. In other localities, the ore is too much mingled with siliceous matter, or other impurities, to work well in the furnace by the ordinary mode of treatment. The beds of iron ore, in common with most of the rocks of Ohio, dip slightly to the E. and E. S.E., and lie one over the other, like the leaves of a book, so that they emerge in succession upon the surface. It is unnecessary to enter into any detail here, on this subject, as Professor Briggs, in his report on Jackson and part of Lawrence, and the adjoining counties, will give the necessary details. His report will tend to show the immense value of the future iron trade of Ohio, which may, at no distant day, rival South Wales, the great Coal and Iron district of Great Britain.

As the iron trade is beginning to be an important one in this State, it may not be inappropriate to make a few remarks upon the principles involved in the reduction of iron ores.

It has, always, been found to be an advantage to roast the ore previous to smelting, not only in consequence of the improved quality of the iron, but because an actual economy in the use of the combustible is effected. Some iron ores, containing more or less of sulphurets, make iron so inferior in quality as to be useless, but which, if roasted, and then exposed to the action of the air and rains, for a year or two before smelting, would make good iron. The cause of this is, that the sulphurets, arseniurets, &c., are disposed to chemical changes after roasting, and, when exposed to the weather, are converted into sulphates, arseniates, &c., which are dissolved and washed away by the rains. It is considered as an established fact, that iron ores are improved by exposure to the weather, so that they may make a purer and tougher iron.

Another object* in roasting the ores, is to render them porous, so that the carbonic oxide, (which, mixed with nitrogen, passes up through the body of the furnace,) may permeate the fragments, and deoxidize them.† If the fragments of ore were impermeable to the

* Another object still, is to make the ore more frangible, that it may be easily broken into fragments of a suitable size for smelting.

† The oxygen of the air, thrown into the furnace through the blast-pipe, combines with carbon, and forms carbonic acid, which, in contact with carbon at a high temperature, combines with another proportion of carbon, and forms carbonic oxide. We see the combustion of this gas in the blue flame of our fires, in which coke or charcoal is used. Carbonic acid is re-formed by this combustion.

carburetted gases, their surfaces only could be reduced. As the iron, when first reduced, is in the state of soft iron, it is infusible until it combines with a certain amount of carbon, and a long time would be required to reduce and melt the successive coats of iron on the surfaces of the fragments. In well regulated furnaces, the ore is broken to a suitable size; and each charge, after being introduced into the furnace, becomes reduced and carburetted in succession, so as to melt after the expiration of about the same time.

If the iron, as it melts, should fall down in naked globules of metal before the tuyere,‡ through which the blast is supplied, they would burn and be reoxidized; and in consequence, the oxide would flow off in the slag, giving it a black or green color. Thus, we see the necessity of conducting the smelting operation in such a way, as to have the globules of melted metal *covered with glass*, as they fall into the crucible of the furnace before the tuyere.*

This is one of the great objects of a flux. A flux is such a substance, or mixture of mineral substances, as will unite with the impurities of the ore to form a glass, which will coat over the metal as fast as it is reduced and ready to flow. It is necessary for the metallurgist, not only to have such a flux as shall combine with the impurities of the ore,† but that its fusibility be so proportioned as to melt at about the same time as the metal. Should it be too fusible, it would melt before the iron would be deoxidized, and dissolve the oxide, which would flow off in the slag, and besides, exercise a powerful solvent action on the boshes and crucible of the furnace. If a little less fusible, it would coat the reduced iron before it should become sufficiently carburetted, and thus prevent its becoming fusible. It would, in consequence, either clog the boshes, or form a salamander, as it is called, of semi-malleable infusible iron, which frequently renders it necessary to tear away the lower part of the furnace, causing much loss of time and money. If the flux melt with too much difficulty, the melted iron falls naked before the tuyere, becomes reoxidized and passes off in the slag, which frequently clogs the furnace, and sometimes suspends its operations. Even if it should not clog the furnace, such globules of metal as were not burnt before the tuyere, would not sink through the semifluid cinder, but lodge in it, so that either no iron could be drawn from the crucible, or its usual quantity would be much diminished.

The uniformly successful prosecution of the reduction of ores, requires a combination of practical and scientific knowledge.

The study of metallurgy has been but little attended to in the United States, and there is no institution in our country where it is systematically taught. A School of Mines is very much needed in the United States. Several of the European Governments support such schools

* Another object of fluxes, in the working of some varieties of ore, is to render refractory minerals, in the ore, fusible.

† Different iron ores, or else those from different localities, are mixed in the furnace, so that the impurities of the ores may flux with each other.

‡ Pronounced *twers*.

with a liberality commensurate with their importance. Our own country bids fair to draw as much wealth from her mineral treasures, as from the cultivation of the soil; and a School of Mines is highly necessary to facilitate the acquisition of such knowledge, as is indispensible for conducting mining and metallurgic operations.

Limestone.

Limestone is the most extensive deposit in the State. It is the rock nearest the surface, over about one-half its area, and probably underlies the whole at a greater or less depth. It is accessible, at no great depth, in many districts where no rock is visible at the surface. It is adapted, in different localities to various purposes, such as for lime, building stones and marbles. Localities will be indicated in the detailed reports. It is believed that hydraulic cement may be made from some of our limestones.

The analysis of the limestones will soon be commenced, with a view to determine their adaptation to the manufacture of lime, and of hydraulic cement.

Limestone is, undoubtedly, the most valuable building material among the rocks of Ohio. Many of the beds yield a beautiful material, which is easily dressed. It stands the vicissitudes of our variable climate, and will endure unchanged for ages, in architectural structures.

The limestone district of Ohio has not been examined, except by a slight reconnoissance. In a scientific point of view, and perhaps in a practical one also, it does not yield in interest to any in the State. Lead ore (galena) has been found in many places in small quantities, and it is not improbable that valuable deposits of this mineral may be developed during the progress of the survey. Most of the lead mines of England, are in a limestone which is probably a geological equivalent to the extensive and thick limestone deposit of this State.

The fossil remains, which are found entombed in myriads in this rock, afford indubitable evidence that it once formed the bed of the ocean; and present a wide field for the investigation of the palaeontologist. In many localities, the most perfectly preserved specimens of these remains of ancient existence, can be procured in abundance, which will not yield in perfection and beauty to those from the most celebrated localities of Europe, or our own country.

Sandstone.

Sandstone is the predominating rock over a large part of the coal formation of the State. It is extensively used for building and for public works; for hearth stones in furnaces; for grindstones; and some of the fine grained stones of this class when homogeneous in their texture, are said to have been used for statuary purposes, and preferred by the sculptor to marble. Some of the varieties of this rock are very durable, showing sharp naked edges on the native cliffs, where

they have been exposed to the elements, during an unknown period of time. Where rocks, which are homogeneous in texture, disintegrate, they show rounded, instead of angular and sharp edged surfaces.

Rocks, unaffected by atmospheric agencies, will stand the test of time, and may be safely employed in public works.

The experience of this country during the past 30 years, has shown how necessary it is to make a proper selection of building materials for public edifices, and more particularly, for the Canal locks and aqueducts, where, by successive changes of wet and dry, and the action of frost, the stone is subjected to the most severe tests of durability. A rock for such purposes, should never be employed in construction, until it has been subjected to the most severe experimental tests. Different beds in the same quarry, often present great differences in their power of resisting the effects of heat and frost, and the chemical action of the atmospheric agents. The Engineer is, therefore, necessarily very cautious in the selection of the materials employed in public works, upon the construction and durability of which he relies for his reputation.

More details in regard to the sandstones examined this year, will be found in the reports of Dr. Hildreth and Prof. Briggs. In addition to these, may be mentioned the export of sandstone from near Cleveland for flagging, building, and for grindstones. Large quantities of this rock for the above purposes, and for columns, are sent to Michigan. The northern coast of Ohio seems destined to be the permanent source, from which the stone required in the Eastern parts of Michigan and the contiguous parts of Canada, will be drawn.

Clays.

Clay is very extensively distributed over the surface of the State, and will, probably, at no distant time, form an important branch of industry. Bricks are already extensively manufactured in some places. Some of the clays are adapted to making fire bricks, pottery, and glasshouse crucibles, and have been employed for such purposes. The localities of beds of clay, adapted for particular uses, will be made known in the detailed reports, during the progress of the survey.

Peat.

This is an alluvion, which is the result of vegetable decomposition. It varies in its aspect; the best quality is a soft, unctuous, tremulous mud when wet; but when dry, is so compact, as to receive a slight polish. When heated, it burns with flame and a bituminous odour. Ligneous, fibrous, and compact peat are the principal varieties: the two former are of comparatively little value; the latter is extensively used in France and Ireland, and is considered a valuable fuel. It is used, not only for domestic purposes, but also in burning lime, bricks, and pottery. In cold climates, it is formed in moist grounds and shallow ponds, wherever there is an accumulation of vegetable matter.

Decayed trees form a soft, light, spongy mass called ligneous peat: from decomposed grasses and reeds, a fibrous peat is formed, which is light and spongy, several feet below the surface; but at a greater depth it may be of good quality for fuel. Small aquatic plants and mosses, such as the sphagnum palustre, produce peat, which, at a moderute depth, is compact, without fibres, uniform in its texture, and of good quality.

Peat, although rarely seen in the southern, is very common in the northern parts of Ohio. On the Portage summit of the Ohio Canal it abounds, and, although this State is so abundantly supplied with coal and wood, yet peat may become a valuable fuel in those parts, which are remote from our Coal deposits.

Soils.

The soils of Ohio are so rich, that many would suppose them scarcely capable of being rendered more productive. Art, however, is capable of improving many of them, so much as to double their produce.

As we are almost exclusively dependent upon the soil for those articles of food and raiment, necessary to the supply of our animal wants, and, as the annual products of the soil form the largest item in the increasing wealth of the State, it is deemed expedient to consider this subject with some attention. All the richest and most densely populated agricultural districts, are on the transition, secondary, tertiary and alluvial formations. Soils, with the exception of those resulting from alluvial *depositions*, are derived from the disintegration and decomposition of the subjacent materials, and they depend in a great degree, for their qualities, upon their mechanical and chemical constitution; hence, the geology of a territory is a necessary prerequisite in estimating the agricultural characters and value of its soils.

The variations in the productiveness of soils, are due to two general causes—viz.

1st. The mechanical texture of soils.

2d. Their chemical composition.

1st. The *texture* of a soil is a character of more importance than is generally supposed. To form a good soil, its texture should be such as to retain a suitable quantity of moisture for the nourishment of vegetation, and be neither so clayey as to bake and crack in the heat of the sun, or heave by the action of frost; nor so sandy as to become parched, and be mere dust at the depth, to which the roots of plants penetrate. Argillaceous soils have so strong an affinity for water, as to retain a small portion even when heated. There should be a sufficient quantity of clay in soils to enable them to retain 3 or 4 per cent of water when dry, and to convert the other materials into a loam. Perhaps a light loam, properly treated, produces the best crops.

It is also necessary to consider the substratum, in judging of the productiveness of any particular soil. If it be clay, or rock without fissures, the soil, however good in its texture and other qualities, will probably be "cold and wet." If the sub-soil be gravel or sand, the

surface soil is frequently too dry, unless it be a loam so heavy, as to retain a sufficient quantity of moisture for vegetation. Where a clay sub-soil occurs, it often alternates with beds of gravel and sand. Advantage may often be taken of this geological fact to drain wet soils, either by boring, or by sinking wells through the clay, into the gravel or sand below, so that the water will find an outlet in springs at a lower level, where these strata emerge on the sides of hills or ravines. In this way, stagnant ponds and marshes may be drained, not only so as to reclaim unproductive lands, but to render the surrounding country more healthful. These principles may be practically applied in many parts of Ohio.

However poor the texture of a soil, it can always be brought to a proper state of cultivation by art; but, the value of produce, and the price of labor will not often justify the expense. Light and heavy soils may always be benefitted by a proper admixture of clay or sand, as the case may require. That clay and sand are almost always associated, is a geological fact of much practical value in agriculture, as well as in the arts. The occurrence of one, (unless from the effect of some local cause,) is a pretty sure indication that the other may be found in the vicinity. Light dry soils are often injured by removing the small loose stones, which, instead of being an injury, are in reality an advantage, as they not only prevent the evaporation of moisture below the surface, by shading the ground; but, by their slow decomposition, furnish stimulants and food for vegetation, thus acting us a permanent manure.

2.—*Chemical composition of soils.*

The chemical as well as the mechanical composition of soils, exerts a powerful influence on vegetation. Salts, alkalies, and alkaline earths, act as stimulants if used moderately; but if in excess, they are injurious. Many soils contain calcareous rocks, stones, or pebbles, which are continually undergoing disintegration and solution by atmospherical agents; and thus serve as permanent mineral manures. Other soils abound in stones derived from such rocks as contain potassa as a constituent, and by their decomposition, furnish this alkali, in solution to the roots of plants, by which it is absorbed and carried into the circulation, and there acting as a stimulant, remains combined with some vegetable acid. The decomposition of gravel, pebbles and rock has been observed to be a benefit to vegetation; and as the rapidity of decomposition depends upon the surface exposed, it follows, that if such materials be ground fine and sowed upon the soil, like plaster of paris, a more decided benefit would be the result. This has been partially tried with success; and it is to be hoped, that the intelligent farmers of this State will give it a more thorough trial.

Iron, in some states of combination, exercises a beneficial influence on vegetation; yellowish and reddish soils almost always contain iron, and are generally productive.

Marls.

The value of marls for manure is well known. The term marl, in its strict mineralogical sense, means an argillaceous carbonate of lime, but by general usage, marl is an earthy mineral substance (or one which becomes earthy on exposure to the weather,) which, by being spread on the soil, renders it more fertile.

The principal varieties of marl, common in this country, are clay marls, shell marls, and the gray and green sandy marls. Clay marl, and the fresh-water shell-marl are common in Ohio; and these deposits will become valuable at no distant time.

A rock formation of great thickness, occupying a broad belt on the surface of the State, and undoubtedly underlying a large proportion of our territory, seems to be well adapted for use as a marl. It rapidly crumbles and disintegrates on exposure.

Fresh water shell marl is formed by molluscous animals, which secrete lime from the waters of the lakes and ponds, in which they live, to form their shells; and as generation succeeds generation, the dead shells accumulating, form thick and extensive beds of this material. When the pond or lake has shoaled to within a few feet of the usual water level, a growth of plants succeeds; and by an accumulation of vegetable matter, peat and "muck" are formed, and cover the marl. The peat and "muck" near the marl are filled with small fresh water shells, similar to those which have crumbled down to form the proper marl. The pure marl is a white crumbly mass when dry, but unctuous and plastic when wet, and contains a few small white fresh water shells. If vinegar or any acid be poured on it, it effervesces briskly.

The value of fresh water shell marl is well known to some of our intelligent farmers; but few know it when they see it, and still fewer know in what situations to find it. For these reasons, I have particularized its characters and its situations. It performs the same office on the land as air-slaked lime, and is as valuable, while it has not the causticity to injure vegetation. One object in burning lime, for manure, is to reduce it to the state of powder by slaking. The shell marl is already in a pulverulent state, and only requires to be dug from the swamps and ponds and spread on the land.

The use of lime is extending very rapidly in New Jersey and Pennsylvania, and has nearly superseded plaster in some of the counties. "Individuals in the vicinity of Allentown, N. J., employ from 600 to 3000 bushels of lime, per year, according to the dimensions of their estates. It is carted from twenty to thirty miles in some instances. The quantity per acre varies from 30 to 100 bushels, according to the strength of the soil, the largest quantity being used where the land is richest in vegetable and animal matter. The dressing is administered in from five to 12 years. Where the soil is thin it is necessary to plough in the lime the deepest. It is always added in the slaked

state, and generally in the fall of the year. After liming, a crop of buckwheat, oats, or corn is taken off previous to one of wheat."*

In Europe the lime is always allowed to air-slake before it is spread. Where lands are highly limed (and sometimes 200 bushels are used to the acre in England,) it is done only once in a term of twenty-one years. In some parts of France, a dressing of only 12 bushels is employed; and this is repeated every third year. Mr. Pulvis, who has done much in investigating the subject of calcareous manures, thinks this the least expensive and best; and as lime is so cheap, it must be an economical manure. "The advantage of the use of lime may be stated in a few words; it is an essential part of the seed of wheat, and that valuable grain will not grow in any soil which does not contain it."†

It may be well to remark, in this place, that limestones, containing magnesia, will not make a lime suitable for manure, however valuable it may be for cements. Farmers should be careful on this point, else they may fail in the use of lime, and infer that it is not adapted to their soil.

MINERAL SPRINGS.

The mineral springs called the Yellow Springs, and Delaware Springs, are extensively known and much frequented during the warm season of the year. Mineral springs are numerous in Ohio, and the slight investigations already made, may probably justify the conclusion that they may be found in almost every county. The springs at Cleveland and Medina and many other places, which it is not necessary to specify in this report, are more or less known, and have some celebrity in the cure of diseases.

The salt springs are the most important, and in the early settlement of the State, furnished most of the western country with salt, an article indispensible to the wants of civilized man. Before that time, salt was transported on the backs of pack horses, over the Alleghany Mountains, to supply the wants of the early settlers. The history of the Salt Manufacture will be found in Dr. Hildreth's report.

Petroleum Springs and Gas Springs are also numerous about the licks. A record of every locality of these springs should be preserved, and it is hoped that the people, who are acquainted with a thousand local details of the country around them, will communicate them freely to the several geologists engaged in the survey.

ALLUVIAL ACTION.

Action of Rivers.

Alluvial action is busy in effecting changes in almost every part of the State. Hills are in process of degradation, by the washing of rains, and by the sliding of avalanches of earth and rock. Streams are undermining and washing their banks, and depositing the materials

* Shepard's Min Report. of Conn., p. 115.
†Shepard's Min. Report of Conn., p. 116.

in parts more or less remote. A great variety of other causes are tending to change, in a degree, the relative elevation of land, and its geographical position. A few instances only will be given at this time in illustration of this fact.

The Muskingum, at Marietta, is supposed to be double the width that it was at the first settlement on the banks of that stream, in consequence of the trees having been cut down, the roots of which bound the fine loam together, and prevented its being washed away. At that time the bottom of the river is said to have been rock, but, in consequence of its increased breadth, by which the velocity of the current has been diminished, it has been filled up with gravel and sand to a depth of 12 feet. In freshes, the weight of the current of the Ohio is forced against the Marietta and Point Harmar shore. Fort Harmar once stood at some distance from the Ohio river, just below the Muskingum. A well, which was in the centre of the Garrison 40 years ago, is now on the bank of the river, and a part of the wall of the well has caved down with the bank. 100 yards in breadth, at least, must have been removed by the heavy sweep of the current against the bank in high water.

Another cause is tending to widen and shoal the river. The numerous steamboats in passing, throw up a succession of waves on the shore, which wash down more or less of the loam and sand, which are deposited in the eddies and still-water. The water along the shore is seen to be turbid with mud, after the passage of a boat, and it seems scarcely too large an estimate to suppose, that a ton of matter is, upon an average, swept from each bank and transported to other places from every mile in length, of the river, by the passage of every steamboat. If we consider the number of steamboats which daily pass, we shall see, that in a course of years, the effect resulting from this cause will influence the depth of water in some places so as to injure the navigation.

Degradation of the Lake coast.

At Fairport, the bank of the lake has been washed away to the extent of several rods in breadth within twenty years. The alluvial deposits of sand adjacent to the piers, covering an area of several acres, afford demonstrative evidence of the detrital matter having been swept along the shore, by the currents and oblique action of the surf. This detrital matter has, doubtless, been mostly derived from the encroachments of the lake on the adjacent coast. The alluvion, thus formed, is much more extensive on the west than on the east side of the pier. That on the west, is about two hundred yards broad. The transport is mostly from east to west. Near the mouth of the Chagrin river, the same effects are produced; but the destructive action of the surf to the west of the mouth of that stream, is more marked than on the east. The degradation here, during the last eight years, has amounted to a breadth of eight rods. Dr. Card, an old resident at Willoughby, has observed these effects on that part of the coast with much accuracy. There is

a stratum of yellowish clayey loam, to some distance below the surface, superimposed on blue clay, containing boulders, pebbles, and gravel.*

A shingle beach, derived from the boulders, pebbles, and gravel of the clay bed, skirts the base of the cliffs, and protects them from the surf, except during storms and high winds. The heavy N. W. winds drive the surf obliquely on the shore, and transport the sand and shingle to the eastward. A long spit has been formed across the valley of the Chagrin. But a few years ago the mouth of this stream was next the western terrace of the immediate valley of the river. The old mouth has been filled up, and a spit formed of several hundred yards in length. At this time, the mouth of the stream is next the *eastern* bench or terrace. The spit is continually extending eastward, and the stream necessarily cuts away the bank in that direction. The spit and the beaches are composed of sand and shingle, which offer a great protection to the coast; but the ever active surf is continually grinding them up by attrition. The transport at this place, is mostly from west to east.

The combined effects of the surf and land springs in the degradation of the coast, can be seen to advantage, at, and near Cleveland. The general level of the terrace above the lake is from 78 to 83 feet. It is composed of sand, gravel, and loam beds near the surface, sometimes fifty feet thick, in some places lying upon a buff coloured clay. These beds rest upon a deposit of lead-colored sandy clay, or clayey sand of unknown depth. Springs break out on the shore, at the junctions of these beds. These materials wash away very easily, and are borne off in suspension in the spring waters, while the superincumbent masses tumble down, forming ravines and valleys, which continually extend further inland, with lateral branches spreading more and more widely. The hill by the bridge from Ohio City to Cleveland, indicated this kind of action during the past summer; and a small spring of water was silently, and almost without attracting observation, performing more in transporting materials from a higher to a lower level, than the efforts of several men could have accomplished. The bed of the Cuyahoga river is rapidly shoaling, from this cause. The coarse sand forms a bank in the river, as steep as this material can lie in water, and projecting out, like deltas at the mouths of large rivers. This shoaling action will, eventually, either dam up the river and form stagnant water above, or else force it to cut a new channel.

At Cleveland, much earth has been, and stlll is washing down by land springs, and it is only by the exercise of much skill and ingenuity, that some parts have been preserved from gullying out, and undermining the streets of the city.

The shore at Cleveland is washing away rapidly in front of the town. A reference to fig. 2, of the plate will illustrate this mode of

* The boulders and pebbles, enclosed in the clay, are more or less smoothed as if by attrition; and many of them are distinctly scratched, as if dragged in a fixed position over hard rocky surfaces. Specimens are preserved. They were not picked up on the beach, but dug out of the clay itself, where they had lain undisturbed since their original deposition. They consist mostly of granite, and a hard compact blue limestone.

action. The cliffs, undermined by the surf and land springs, crack off at the top and slide partly down, so as come within the action of the surf, while other slides from above, continue to push it farther and farther into the Lake, until all is carried away by the waves and shore currents. Slides occur every year. Several rods, in width, have slidden down and been washed away, within a few years.

Attempts have been made to arrest this degradation, which threatens to remove the site of the city in the course of a century or two, unless it be checked. If piers be erected at intervals, extending out for 100 to 150 yards from the shore, and well filled in, alluvial deposits from the sand swept coastwise by the surf and shore currents, will necessarily be deposited in the eddies formed by these obstructions. An example of the application of this principle may be seen on the West side of the pier which protects the harbor, where several acres of alluvial land have been formed within four years. As the coast *West* of Cleveland is rock-bound, very little detrital matter is swept eastward, while the coast to the east of Cleveland, to Fairport, composed of earthy materials, is mostly in a state of rapid degradation. The northeast winds sweep this detrital matter along to the westward, and deposit it behind the obstacles which create eddy currents. The long pier at Cleveland has caused such currents, and the deposit of the alluvial sands just mentioned.

One evidence that the Lake has been making encroachments on this part of the coast for a long time, is an isolated hillock, a part of the original shore, which was also the boundary of a bluff on the Cuyahoga river. This bluff turned the river westward, so that its mouth was a mile or more West of Cleveland, and remaining without degradation on the river side (as is evident by its moderate slope,) was washed away on the Lake shore, until it was cut through at the bend, and gave the river a shorter course to the Lake through a new mouth. The old mouth is closed by a sand beach, and the alluvial ground mentioned as having been formed West of Cleveland, is partly in front of the hillock, which presents a nearly vertical escarpment towards the Lake.*

The evidence of the degradation of land by the surf on the shore, may be seen at any time by standing on the cliff at Cleveland (and at many other points on the coast,) and looking off upon the Lake. At the distance of one-half to one mile from the shore, a distinct line may be seen to mark the division between the muddy water, produced by the washing away of clay and the grinding up of pebbles on the coast, and the clear blue water of the Lake. All the water between that line and the shore is tinged with finely divided matter in a state of suspension. This matter settles in still water, and, probably, forms clay on the bottom of the Lake, imbedding shells and other organic remains.

From the facts which have been mentioned in relation to the alluvial

* The topographical map of Cleveland, vide fig. 1, of the plate, indicates the old and new mouths of the river; and the new mouth is now filled up, in consequence of the river being confined between the piers.

action on the coast, it will be seen that the direction of transport is sometimes eastwardly and sometimes westwardly. This is dependent upon local causes, such as the trend of the particular line of coast, the prevailing direction of winds, the angle at which the surf rushes to the shore, the direction of eddy currents, and the peculiar position of parts of the coast, which are washing away. From the facts which have been mentioned, it is believed that the aggregate amount transported from East to West is greater than in the opposite direction. One fact, especially, gives weight to this deduction, viz., the prevailing strong winds, which affect the South coast of Lake Erie, are from the N. E. to N. W. The winds from the latter direction throw the surf nearly perpendicularly upon the shore, so as to grind up the shingle, and undermine the cliffs, without causing distant transport, while those from the former direction roll the heavy waves obliquely along the shore, producing currents, which, together with the surf, transport the materials from place to place, and deposit them in sheltered situations.

It is stated, that the coast of Lake Erie is undergoing a more rapid degradation by the action of the waves, than it did in former years, and the reputed cause, is, that a dam partly across the outlet between Buffalo and Black Rock, obstructs, in some degree, the drainage of the Lake. Any obstacle at the outlet, which checks the rapidity of the current, must obstruct the drainage, and, in consequence, the level of the Lake must necessarily rise, until the escape of water, by drainage and evaporation, shall equal the supply. The rise of water exposes that portion of our coast, where it is not rock-bound, to inroads from the Lake by overflows, or to more rapid degradation by the waves.

The owners of the dam at the outlet of the Lake, must necessarily be liable for such damages sustained by our citizens on the coast, as result from the obstruction referred to. Data are being collected, by means of which the relative amount of degradation for distinct periods of time, in particular localities, may be estimated.

Analysis of Coal and Ores.

The analysis of the coal and iron ores, the localities of which were examined during the last season, will be soon commenced, with a view to ascertain their adaptation to the manufacture of iron. Although iron is smelted so extensively in England, by means of bituminous coal, and the coke obtained by charring it, it is believed that only three furnaces are operating with these combustibles in the United States, and two of these are in Ohio.

It is believed that there are many coal beds in Ohio of a quality suitable for smelting iron ores. Chemical analysis will ascertain the probability of their adaptation to the purpose; still, as as matter of prudence, works should not be erected until a successful trial of the coal and ore has been made.*

* Coke is now manufactured in Ohio from several of the coal beds. Hon. Daniel Upson of Portage County, makes a coke of excellent quality from the coal of his mine in Tallmadge. Mixed with charcoal, it is used in the high furnace at Akron, in the smelting of iron ore. Mr

If our coals should prove to be pure enough for smelting iron, Ohio has the elements of unbounded wealth beneath her soil, and she may become the most productive iron district in the world.

Importance of determining the Dip.

The dip, or the angle by which the planes of the strata plunge below the horizontal plane, is so small in most parts of this State, that the determination of its approximative amount becomes an important element in the determination of the subterranean value of our lands. Important mineral beds, such as coal, iron ore, limestone, &c., although they may not show themselves on the surface of the earth, even in the deepest valleys of a particular district, may yet lie so near, as to be capable of profitable exploration; hence, the determination of the mean dip of the strata is an indispensable datum in determining whether they lie at such a depth as to be valuable. The strata dip so slightly, that beds of moderate thickness occupy a belt of considerable breadth; and in the direction of their dip, such as are valuable, may be explored with profit, at a distance of many miles from the place where they form the surface.

There are various means of determining the amount of mean dip over extensive tracts of country, all of which will be employed, and serve as checks to each other. Instruments have been procured, by means of which the exact amount of local, as well as the general dip, will be observed, in as many places, as may be thought proper, and the faults and undulations, although not visible on the surface, may be ascertained, if they exist. The Topographer of the Geological Survey, Colonel C. Whittlesey, has obtained the levels of a great number of points, by consulting the records of the Board of Public Works, and the various surveys for the internal improvements in the State. Many others will necessarily be determined by his own observations in the discharge of his appropriate duties. The determination of the various levels has many important practical bearings, and there is one which will be, ultimately, of much scientific interest. Elevatory movements have taken place on almost every part of the earth's surface at different periods. Some of them have occurred within the historical epoch, and even now, Sweden is said to be gradually rising above the level of the Baltic sea.

These levels above the ocean, will be standards of reference, which will determine whether such effects are now in progress.

Organization, Duties, and Estimates.

The geological corps has been organized upon the basis of the act of the 27th March, 1837, with the intention of developing the natural resources of Ohio, and furnishing complete catalogues and descriptions

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Ford, of Akron, by mixing 40 bushels of coke per day with the charcoal, is stated to have increased the quantity of iron smelted 33 1-3 per cent. The coal bed is from 3 to 5 feet thick, and from 2 to 3 feet of the coal makes excellent coke, which is found to be a perfect substitute for anthracite coal in the cupola furnaces.

The time cannot be far distant when our iron masters, like those of Great Britain, will depend exclusively on this combustible for smelting.

of all her natural objects. It is proposed, also, to make a comprehensive *collection* of the natural productions, so as to exhibit under one roof complete suites of specimens of the animal, vegetable, and mineral kingdoms.

With a view to a perfect and rapid accomplishment of the varied duties of the survey, several distinct departments have been created, appointments made, and to each individual an appropriate sphere of duty has been assigned.

Dr. S. P. Hildreth of Marietta, who has been long engaged in investigating the fossil remains and the geology of the rocks of Ohio, was appointed as first assistant, and directed to take charge of a department, embracing the description and figuring of the organic remains found entombed in our rocks.

It was deemed expedient to have a *palæontologist* engaged in the geological survey of the State. All the branches of natural history and many of the other sciences, cluster around geology, and lend to it, and to each other a mutual support. No man can make great advances in *all* the branches of geology; the proper course to be pursued, is for each individual to become acquainted with the great outlines of the subject, and then devote his attention to some particular branch of enquiry. It is by such a division of labor, that geology has advanced so rapidly within a few years. Physical geology and palæontology are distinct branches of enquiry. The palæontologist must, necessarily, be minutely familiar with the various branches of natural history, to distinguish the minute shades of difference in the species of fossils, and consult many authors to know what has been described and figured by others. The geologist must have the *results* of such labors, before he can draw definite conclusions on some points of geology. It is believed that this division of labor will facilitate the perfection of the work, by enabling each individual to devote more attention to his specific branch of enquiry.

Dr. Hildreth, in consequence of his infirm health rendering it impossible to discharge the laborious duties of his department of the survey, is about to resign. I may here be allowed to render a tribute to this gentleman who has been a resident of Ohio for nearly half a century, and for many years been ardently devoted to geological investigations in this section of our country. He has published several geological and other papers, which are valuable both on account of the economical and scientific facts which they contain. He saw the prospective value of the mineral beds of our territory, and exerted himself to procure an act authorizing the geological survey of the State.

It is intended to avoid all discussion involving theories and theoretical considerations, in the *annual reports*. They are intended to be entirely of a practical character, containing statements of facts, developments of our mineral resources, and such information as may aid our citizens in applying the mineral wealth of the State to practical purposes. In consequence of Dr. Hildreth being about to resign from the geological corps, some theoretical deductions, to which he has arrived, are contained in his report; but in general, such discussions are to be

retained for publication in the final report after the conclusion of the survey; when, it is believed, such masses of facts will have been accumulated, as to leave less chance of error, than if deductions were made from the results of each year's examination.

The buhrstone, termed by Dr. Hildreth the calcareo-silicious rock, is an important mineral deposit, and it involves as much of scientific interest in its mode of formation, and the contained fossils, as in its useful applications. Dr. Hildreth has described the members of the coal series which lie above the buhrstone.

The history of the Salines of the State, and numerous facts in relation to them, are contained in his report, and will be read with much interest by all.

Prof. J. P. Kirtland, of Poland, now of the Ohio Medical College, at Cincinnati, was appointed the second assistant, and directed to take charge of the department of Botany and Zoology, which involves a description, and the completion of catalogues, of all the living organic matter of the State. It embraces the development of the best modes of culture, of improving our stock, of obviating the destructive influence of the blight, mildew, and insects, and a great variety of topics, which are not only of interest to science, but of high practical importance. By a knowledge of the habits of insects and animals, it can scarcely be doubted, that the farmer might be secured in the enjoyment of the fruits of his labor, where he now frequently laments over his ruined harvests.

Dr. Locke, the 3d assistant, was in Europe at the time of his appointment, and did not return until the field duties of the season were about to close. He has not, therefore, performed any duty on the Geological survey.

Professor Briggs, the 4th assistant, assisted by J. W. Foster, Esq., of Zanesville, entered upon his duties in July last. These gentlemen were actively engaged in the field duties of the Geological Survey until the 20th of November. Mr. Foster was appointed as an acting assistant, and associated with Prof. Briggs in the survey of the district lying between the waters of the Scioto and Great Hockhocking.

Col. Charles Whittlesey, of Cleveland, was appointed to take charge of the Topographical Department of the survey, and has been actively engaged in the numerous and laborious duties of his office. He has furnished skeleton maps of townships and counties to the Geologists proper, and collected all accessible information from the Land offices and public records, in relation to the boundaries of counties, towns, courses of streams, &c., preparatory to the construction of a topographical map of the State.

The amount of information thus obtained, is much less than it was supposed could be procured from those sources, the reason of which is fully detailed in Col. Whittlesey's report.

The topographical map of the State, if accurately constructed, will indicate the whole contour of the ground, and the physical character of the country, as if it were actually spread before the eye of the observer, showing, at a glance, its plains and mountains, hills,

valleys, streams, bottom lands, swamps, marshes, woods and cultivated fields.

On such maps, the localities of all minerals, ores, rocks, &c., can be indicated in their proper position and relations to each other.

The great objections to our present maps are, that a level country is indicated where it is a labyrinth of hills; that boundaries of townships and counties are often erroneous; and streams are indicated far from the positions where they actually flow.

An accurate topographical map would require a triangulation similar to that of the national coast survey, which has been in progress for some years. The time and expense of accomplishing such a survey would be greater than the Legislature would, probably, deem expedient to appropriate for its completion. Such a survey, however, once accomplished, would never again be necessary. The importance of such a map, for a multitude of purposes, besides its basis for a geological map, is well known.

The appropriation for the continuance of the survey, must determine whether the topographical department be conducted upon the principle of accurate triangulation, or adopting the divisions of counties, townships, sections, &c., as bases, and filling up, by slight admeasurements, and sketches by a *coup d'oeil.* A *trigonometrical* survey of the State would require an expenditure, of at least $100,000 for its completion.

In conformity with the spirit of the act authorizing the Geological Survey, the Topographer, Col. Whittlesey, has also been instructed to survey the remains of ancient works, which are so numerous within our territory. The plans and descriptions of these works will be given in the final report. Col. Whittlesey's slight notice of some of these will be found in his report, which is annexed.

In addition to my proper sphere of duties, of superintending the survey, and visiting the more important localities, the department of chemical analysis will be conducted by myself, and under my immediate supervision. Ores, mineral waters, coals, and all mineral substances, will be analyzed, if there be a probability that they may be capable of useful applications.

As the primary object with the Legislature, in authorizing the Geological Survey of the State, was to develope its natural resources, with a view to their application to the economical purposes of life, it is, of course, an object to have it accomplished at as early a day, as is consistent with its proper execution. It is, therefore, respectfully suggested, whether it be not expedient to so modify the act, authorizing the survey, that a greater number of individuals may be employed in its different departments.

If the corps be increased, so as to give one more assistant to the survey, and the Geologist authorized to employ, temporarily, such individuals as may be necessary for local purposes, the expense will be but little increased, while the number of persons employed, and the amount of labor accomplished, will be more than doubled. There are numbers of our young men who might be usefully employed in this

enterprise, and with a small compensation, would engage in such duties, merely with a view of acquiring practical knowledge.

I consider it a duty to make the above suggestion, as the total amount necessary for the accomplishment of the work, will be less, while our citizens can be reaping the benefit at an earlier day.

If the present organization be continued, as under the existing act, the necessary appropriation for the current year will be $12,000.

If the suggestion, above mentioned, for increasing the corps, and employing acting assistants, be adopted, it will be necessary to inincrease the appropriation for the current year to $16,000.

If the topographical survey of the State be continued, as at present, no expense above the appropriation mentioned, will be incurred; but if the State be *triangulated*, for the topographical survey, the appropriation for the current year, should be $30,000.

I have the honor to be, sir,

Your obedient servant,

W. W. MATHER,

Principal Geologist of Ohio

REPORT

OF

DR. S. P. HILDRETH,

FIRST ASSISTANT GEOLOGIST.

No. 2.

To Professor W. W. MATHER,
Principal Geologist of the State of Ohio.

SIR: The most favorable portion of the season for field operations being considerably advanced before the corps for the geological survey of the State could be organized, the results of individual observation cannot be so great, as they otherwise might have been. Our researches have been wholly confined to the coal measures; and of this district only a part has been examined. It embraces all the south eastern, and north eastern sections of the State, and abounds in minerals, the most important of which are coal, salt, and iron ores. It also contains valuable deposits of quartz rock, marl, lime-stone, clays, and a great variety of fine and coarse grained sand rocks, for architectural and other useful purposes. Through the whole of this region, the rock strata are arranged in regular series, and the different beds so placed, as to be the one subordinate to another, over large extents of surface. And although to the eye of the casual observer, they may seem to be in the utmost confusion, yet the greatest regularity prevails in the arrangement of the different deposits.

So far as this State is concerned, and it contains but a small part of the coal measures of the valley of the Ohio, the rock strata appear to have been but little disturbed since their original deposition from the ocean of waters, that once covered the whole valley between the Rocky and Appalachian ranges of mountains. There is a general, but gradual dip of all the strata towards the centre of the valley; so that, on the western border, the dip is easterly; on the northern, southerly, and so on, with great regularity, until we approach the more mountainous portions, when this order is broken in upon, and the inclination is acommodated to the ranges

of mountains, which have evidently been raised at a period posterior to the deposition of the coal measures.

The regularity in the dip, and moderate inclination of the strata, afford facilities to the miner, not known to those of most other countries, especially, in Great Britain, where the coal not only lies at great depths below the surface, at a high inclination, but the strata, in which it is imbedded, have been broken and thrown out of place, since their deposit, occasioning *slips* or *faults* of many feet, sometimes of several hundred; causing much labor and expense in again recovering the bed, which is to be sought either above or below the spot cut across by the *fault*. In the coal beds of Ohio, very little difficulty of this kind is experienced. *Faults* or *slips* of a few inches or a few feet, are sometimes met with, which have been occasioned by slides or the gradual settling of the earth from the undermining of the hill sides by water courses, or springs, rather than from any force from below.

The ease and facility with which coal is mined in the west, where the beds are generally opened at the base, or in the side of a hill, in the coal itself, and drifts carried under horizontally, will be better shown by contrasting it with the process of mining in Great Britain.

In Northumberland, the Newcastle coals, which are most familiar to us, are brought up from great depth, and at a heavy expense, by sinking *shafts* or *pits*. Steam engines are used for raising the coal and freeing the mines from water at this place. The upper, or *main bed* lies at 450 feet, and is six feet in thickness. The *lower main* lies at 810 feet, and is 6½ feet. Between these two there are eight thinner beds, one of 4, and one of 3 feet; the rest quite thin. In the whole, there are 40 distinct beds in this coal field, which is 58 miles in length, and 24 miles in its greatest width. In all these beds they count on 30 feet of workable coal. They have many other smaller fields in different parts of the island.

In Somersetshire, some of the shafts have been sunk to the depth of 1,200 feet. The beds here are from eighteen inches to nine feet in thickness, and 23 in number, making 95 feet of workable coal, over a space of 100 square miles.

In Staffordshire, at 360 feet, they find a bed of coal that is 27 feet thick. It is, however, divided into several portions by thin seams of slate clay. These beds are highly inclined at an angle of from 10 to 45 degrees, so that in a few miles they sink to a great depth. Similar deposits of argillaceous iron ores, accompany the coal as in Ohio, and furnish nearly all the iron manufactured in England. The rocks which lie over the coal are generally much less inclined, and sometimes nearly horizontal. They are new red sand-stone, lias, oolite, &c. The two latter are rocks, which have been very partially, or more probably, not deposited at all over the coal measures of Ohio.

That portion of the coal measures of the valley, which lies within this State, occupies a space of about 180 miles in length, by 80 in breadth; extending in a south westerly and north easterly direction along the border of the Ohio, from Trumbull county to the mouth of the Scioto. These immense fields will furnish fuel for a larger population than the soil of Ohio can support for ages; and when the surface beds are exhausted, much thicker ones will be found by sinking shafts to the depth of a few hundred feet, as all coal beds are thinner in their out-crop, or near their margins, than in the center of the basin. Of this fact we have proof, not only from foreign fields, but from the disclosures made in boring salt wells in our own State.

Although a considerable portion of Ohio is hilly and broken, yet we have no mountain ranges, and our hills are hills of degradation, or made by the wasting away of the original rock strata and earth by the continued action of rains, frosts and running waters, in the course of unknown ages. That there was once a period, when the valleys between the hills were all united and in juxta-position, is made evident from the fact of coal beds, sand rocks, &c., which are found at a certain elevation in the hills on one side of a valley, being also found at the same, or nearly the same height on the opposite side, although the distance between may be more than a mile; as may be witnessed at many localities on the Ohio river, or any of the smaller streams.

It is probable, that the larger portion of this cutting, or wasting process, was accomplished soon after the receding of the oceanic waters, and before the earth was clothed with the present families of forest trees; and while yet in the vicinity of large bodies of water, the climate was probably more humid and milder than at this time, affording a much larger annual amount of rain similar to that of tropical climates in the present era of the earth. From the fact of the lower series of rock strata, which compose the coal measures, terminating on the outer margin of the basin in heavy masses and abrupt precipices, as in the vicinity of Lancaster, in Fairfield county, and several other places near the borders of the great lime-stone formations, which occupy the middle and western portions of Ohio, and being also indented, similar to the bays and head-lands of a modern sea coast, we are led to conclude that the coal measures were gradually raised by successive depositions on the bed of a sea, and formed an island or islands on the borders of the ocean which then covered the larger portion of the valley of the Mississippi. We are led to draw this inference from the fact that no boulders, or erratic blocks are found far within the present coal measures, but only on their northern or western borders, while the surface of the prairies and the country west of the coal series is profusely dotted with these fragments of a primitive formation. The most plausible theory of their origin is that of their having been brought by currents from the north, imbedded in ice, at a period anterior to the formation of the Allegheny ranges of mountains, when the present "Gulf stream" flowed over the regions which now compose the western states. These floating masses of ice and earth, meeting with the warmer currents of the south, gradually melted and deposited the imbedded fragments on the bottom of the ocean, in the same manner that the icebergs of the present day are scattering the ruins of the north over the banks of Newfoundland, and the latitudes yet further south.

From Lake Superior to the coast of Florida, there is to be found in the rock strata, every evidence we could ask in countless millions of the reliquiæ of oceanic life, that a sea once covered all the region now watered by the tributaries of the Mississippi. The strata which compose the coal series have been deposited from water. Some of them, especially the slate clays, apparently from a quiet medium, while the sand-stones and coarse conglomerates, bear in their structure evident marks of having been thrown down from a moderate current, or one of greater rapidity, according to the size of the component particles. Where the vertical face of a deposit is fairly exposed, as in the sides of large grottoes, their wave-like structure is beautifully shewn; in some localities imitating the appearance on the bed of a stream, and pointing out, by the arrangement of the particles of sand and mica, the course from which the waters flowed. These are all formed from the detritus of other and older rocks; having in their

composition, mica, quartz, feldspar, &c. From the disintegration of the primitive and transition series, in a coarse or more finely comminuted state, the present secondary rocks are constructed; the particles being generally cemented either by calcareous or argillaceous matter. In some instances, the uniting material is silicious and ferruginous, when an exceedingly hard rock is the result.

How far these views of the original condition of the coal measures, and the formations west and north of them, can be supported, must depend on the discoveries yet to be made in pursuing the geology of Ohio, which is only in its incipient state.

With these preliminary remarks, we will now proceed to a more particular description of the rock strata of the eastern part of the district of country traversed in my researches as "Palæontologist, and assistant Geologist;" my more especial duties being to collect, describe and arrange the fossil organic remains, both of a vegetable and animal origin, that may be found in the State. While on these tours, it has been a leading object to trace out the direction and extent of the great quartz deposit, or calcareo-silicious rock, which, like a zone, encircles a large portion of the width of the State, and discover the muriatiferous or salt producing rocks, and also the main ferruginous deposits. It is one of the most interesting features in the geology of the coal measures of Ohio, and, like the meridian line in geography, will afford a valuable guide in developing the series of rock strata which lie beneath, or are superimposed on this deposit. The early history of the salt manufacture, as intimately connected, not only with the geology, but with the vital prosperity of the State, will also receive such notice as my present limited store of facts can afford. The descriptions of the fossil organic remains will be chiefly deferred, until the final report of the survey.

Description of the rock strata which lie over the "Buhr-stone" or calcareo-silicious rock, on the west side of the upper coal measures.

Mr. Briggs, in his report, having described the rock strata which lie below the calcareo-silicious deposits in the lower part of the coal measures, I shall enumerate those which lie above it, as they were noticed in my explorations on the west side of the Muskingum river, in the counties of Meigs, Athens, Perry, Muskingum, Morgan and Washington.

This enumeration will nearly complete the series of the coal measures, terminating with these, which are the most recent near the central part of the basin on the Ohio river. For the convenience of description only, they are arranged in numerical order, subject to such alteration hereafter, as the more minute and detailed surveys may discover to be necessary, and will probably be needed. The principal object of this description of strata, being to give a tabular view of the order of arrangement in the series above the Buhr-stone deposits.

From the undulating position of the rocks in some places, the dip of the strata varies, very considerably, even in short distances; presenting, in this respect, the difference of from 10 to 50 feet in a mile, but the general inclination of the whole, on the western side of the basin, is to the east and south east.

No. 1.—*Calcareo-silicious deposit, or Buhr-stone rock.*

This being one of the most interesting members of the series, and serving as a guide to the deposits above or below it, independent of its great

value for economical purposes, will receive more notice than any other rock. Its external and most common appearance, as a silicious or quartz rock, is so peculiar as to be readily recognized by most observers; and where it assumes its calcareous character, as it does in many places, it may be known by the imbedded fossils which accompany this rock in its whole course.

Range and extent.

In its range, this deposit embraces all the western borders of the coal measures in its out crop on the hills extending from the Ohio river in a north, and slightly east direction, to Stark county; beyond which, north-easterly, it has not been traced. Its average breadth may be estimated from 12 to 15 miles; widening out in some places to 20 miles, which will include its extreme westerly outliers on the hills, to its easterly dip, or disappearance below the beds of the rivers and creeks.

In travelling westerly from the mouth of the Muskingum river, we first meet with this rock on the west side of Alexander township, in Athens county. It is here seen in the left bank of Margaret's creek, just below Mr. Toppin's mill, about seven miles in a south west direction from the town of Athens. The deposit is six feet in thickness, where it appears to view, but is probably thicker, if it were uncovered. It lies in layers or beds of from six to ten inches in thickness. The color of the rock is dark grey, and holds a large share of lime in its composition, as is the fact at many other localities farther west. When removed from the quarry, as it frequently is, by the inhabitants of the vicinity, from other beds besides this, for underpinning their houses, laying cellar walls, &c., it is often found ready split to their hands, in parallelograms and prismatic pieces, with smooth, plane faces, suitable for window sills and caps, or building up in a wall without any additional dressing, except to square occasionally a rough extremity. The same deposit is exposed in the beds of the streams for several miles west, in the township of Lee. At this locality, a bed of loose sand-stone lies over the calcareo-silicious rock, and a dark shaly stone beneath it. At some localities further west, a bed of coal is found a few feet below; and still further west, it rests immediately on the coal. The rock at Toppin's mill contains the characteristic fossils peculiar to this deposit, such as encrini, producti, spiriferi, terebratulæ, &c. In travelling westerly, in Lee and Brown townships, loose and broken fragments of the rock are discovered in the beds of runs, and occasionally it is seen to crop out in places on the sides and points of hills. On section No. 16, in Lee, near the house of Judge Warner, it crops out by the side of the road, where the water from a spring has laid it bare. Here it is 8 feet in thickness, lying in regular strata of 8 or 10 inches. It contains a considerable portion of lime in some of the upper layers, while the lower are nearly pure quartz and horn-stone. The color is various, from brown to black, green, blue and horn color. The cross fracture is conchoidal, while the division by stratification is into plane surfaces. The lower bed, where it approaches the coal, is nearly black. Near the top of the bed some portions assume that open cellular structure which renders it so valuable a material in the manufacture of mill-stones. This peculiar feature in its character, however, so far as I have observed, is chiefly confined to that portion of the deposit which lies within a few miles of its western limits. West of Lee, in the northern part of Brown township, the calcareo-silicious rock crops out at a gap in a high ridge, and large fragments of the compact quartz are scattered over the surface.

Where it appears in the heads of branches, it has not assumed the texture of buhr-stone. It is, however, so seldom seen in large beds until it reaches Elk township, that it is difficult to decide on what may be its true character, until quarries are opened extensively. In the south west corner of Brown, are some beds of buhr-stone that appear to be equal in quality to those farther west. In Elk, which is 24 miles south westerly from the town of Athens, many valuable quarries of mill-stone rock are opened; some of them have been worked since the year 1807.

In Richland township, Jackson county, the buhr-stone is found 8 miles west of McArthurstown. It appears to terminate on the west side of this township, on the tops of the hills, and has been the uppermost stratum for several miles east of this point. Here it assumes a different texture. The quartzy portion has evidently been broken into fragments, which have the appearance of being water-worn like pebbles on a beach, and afterwards cemented by sand and iron similar to a conglomerate or pudding-stone.

This locality is near Mr. Redfearn's, on an easterly branch of the middle fork of Salt creek. Near the western termination of the calcareo-silicious deposits, the coal which lies a number of feet below it in Lee, has approached to within a foot or two, and in some localities, is directly under it. The coarse sand-rock over it is, in some places, entirely wasted away, or run out, while in others it has crumbled into a bed of sand. The buhr-stone is seen in nearly all the hill sides for many miles from below the elevation, where it is in situ, to near the bottoms of the hills, having gradually slidden down with the earth in the course of ages; and being of an imperishable quality, it remains, while other rocks are decomposed and washed away. To the north west of Richland, this deposit is traced on to the heads of the Raccoon creek and the Honey fork of Queer creek, in Hocking county, while to the south it continues on in rich beds of buhr-stone for 12 or 14 miles in length, by 6 or 8 in breadth. On the east side of Jackson county, in the townships of Milton and Bloomfield, the calcareo-silicious rock is found dipping gradually down to the base of the hills; and near the middle of Wilkes township, in Gallia county, by the bridge which crosses Raccoon creek, it lies only a few feet above the bed of the stream. This locality is 4 miles west of the village of Wilkesville. To the east of this line, it appears no more above the water courses. The hills rise over it, and the bed of no stream east has been cut to a sufficient depth in the superincumbent strata to bring it to light, but it is passed at very considerable depths on Leading creek and Chickamoga, in boring for salt water. South of this place, the out crop of this deposit takes a more south-westerly direction, while the course for 12 or 15 miles north of this, has been very nearly north and south. Still pursuing a south westerly line, it crosses the westerly extremity of Gallia county, and is found in abundance on the head of Symmes creek, in Lawrence, and from thence to the Ohio river. In tracing the line of bearing in a north easterly direction from Jackson county, we find this rock cropping out on the hills on the eastern side of Hocking county, and the corner of Athens, in York township. In the latter township, it is quite silicious in its character, and were it more cellular, is sufficiently hard for mill-stones. It is regularly stratified in a bed of 8 or 9 feet in thickness, on sections 9 and 14, in town 12, range 16. The same coarse sand-rock lies over it, as in Jackson county. The farthest west where the quartz was seen in Hocking county, is in range 16, town 12, section 4, in Swan township. North of this, it is found only in detached fragments lying on

the tops of the ridges, which can only be explained from the preponderance of lime in its composition over this region, which, having decomposed in the course of ages, has left but few relics of its existence as a regular deposit. The same remarks may be applied to the country on the east side of the Hockhocking river, where detached fragments only can be found until we reach the north east corner of Green township. Here, and in Monday creek township, it is occasionally seen in place near the tops of the hills, and in fragments amongst the debris in the beds of the streams. As we progress northerly in Perry county, it becomes more abundant; and at Lexington, in Pike township, the calcareo-silicious rock is seen in continuous masses, lying on a level with the present alluvions of Rush creek. It is here nearly pure quartz, and has not wasted away by the action of the elements, being in a manner imperishable. This enduring quality has enabled it to maintain its present position, while the softer, underlying rocks have disappeared, by the wearing action of the stream. It is so compact and silicious as to have attracted the notice of the aborigines, who have manufactured it largely into arrow heads, if we may be allowed to judge from the numerous circular excavations which have been made in mining the rock, and the piles of chipped quartz lying on the surface. From thence northerly, it may be traced across the length of the county, bearing north easterly into the corners of Licking and Muskingum counties. Here it lies on the tops of the hills for many miles in extent, forming what is called "Flint Ridge," a locality well known to that region of country. In the two townships of Hopewell, it lies on the surface in extensive masses, and has been an object of peculiar interest, both to the aboriginal and present inhabitants of the country. To the former, from the most remote periods, it has furnished a valuable material for the manufacture of knives, spear and arrow heads. How extensively it has been worked for these purposes, may be imagined from the count less number of excavations and pits yet remaining, from whence they dug the quartz; experience having taught them that the rock recently dug from the earth, could be split with much more freedom than that which had lain exposed to the weather. These excavations are found the whole length of its out crop, from Jackson to Muskingum, but the most abundantly on "Flint Ridge," from its furnishing a more com pact quartz, and greatly diversified with rich colors. To the present inhabitants it is valuable as furnishing a fine article for mill-stones, as will be more especially noticed in the remarks on that subject.

The buhr-stone in Muskingum county, assumes a different aspect from that in Jackson. The color is lighter, and the cells differently formed. Instead of open fissures, the portions selected for mill-stones, are filled with small, tortuous, vermicular passages, about the sixteenth of an inch in diameter, which, to the naked eye, appear to have been formed by an aquatic worm traversing the mass while in a soft and plastic state, but which, on a more minute examination with a microscope, prove to be the matrices or cells of a small, fusiform, univalve shell, of a genus very similar to rostellaria, but whose species is not yet determined. These, with occasional small joints of encrini, make up the great mass of minute cells which cover the face of a fresh broken fragment of the burr-stone. Occasional specimens of terebratulæ, spiriferi, producti, &c. are seen in the silicious portions of the rock, but they are comparatively rare when contrasted with the calcareous districts in this deposit, where they found more congenial beds, and the rock is now literally filled with their remains. The deposit here is from 8 to 9 feet in thickness. From Hope-

well to the mouth of Licking, a distance of 10 or 11 miles, the dip of the strata south easterly is very small, not more than 10 feet to the mile. Near the top of Putnam hill, at the mouth of Licking, we find a grey, shelly lime-rock in a state of decay, containing the same fossil shells which accompany the calcareo-silicious rock in all the localities I have visited. Between this locality and Hopewell, no indication of this rock is seen *in place*, but fragments are found in the ploughed fields, and occasionally a piece on "Putnam hill;" from which circumstance we are led to conclude that this deposit has been decomposed and changed to soil, from the fact of its containing so large a proportion of lime in its composition.

Proceeding southerly along the waters of Moxahala creek, and parallel with the Muskingum river, we find it lying high in the hills, and especially in Brush creek township, near the south west corner of Muskingum county. Here it assumes a yellowish color and softer texture, resembling a fine grained, buff colored lime-stone. It contains the usual fossils, amongst which terebratulæ are the most abundant. A short distance south, near the north line of York township, in Morgan county, it is seen in place, lying in regular successive strata, and forming a bed of 8 or 9 feet in thickness. From this place, which is about 2 miles north of Deavertown, it can be traced down the waters of Island run, and Oil run, to the Muskingum river, and to a point two miles above M'Connelsville, where it lies on a level with the surface of the water during its low stages. At M'Connelsville, this rock is passed in boring for salt water at the depth of 110 feet below the bed of the river, and is found to be a valuable and certain guide to all the borings below this point. The lower or main salt rock is reached at the depth of about 650 feet below the calcareo-silicious rock, with little variation for the distance of 10 or 12 miles below, or as far as any wells have been sunk; which is a proof that the intermediate strata vary but little in their aggregate, if they do in their individual thickness. The dip of the strata in this vicinity is much greater than I have noticed at any other place. At Campbell's mills, two miles from the Muskingum river, on Island run, this rock forms the bed of the stream, in a smooth regular floor, over which the water falls 15 feet, having cut away the dark bituminous shale which lies under the rock five or six feet in depth. The deposit here is a true calcareo-silicious rock, considerable portions of which are nearly pure limestone. It breaks into irregular conchoidal fragments with a dull lustre, and contains the usual fossil shells. In the bed of "Oil run," two miles south of Campbell's, so named from a spring of petroleum, found about a mile from its mouth, this rock has a very rough, irregular surface, probably occasioned by the wasting and dissolving of the calcareous portions of the deposit, while the harder quartz remains unaffected. From Deavertown to Campbell's, a distance of about 8 miles, there is a dip of 250 feet, and to the river, about 50 feet more. The hills are so high as to contain the 5th, or non-fossiliferous lime rock, of Wolf creek, at 50 feet below their summits. The 4th fossiliferous lime-rock lies at about 100 feet below it, and at least 100 feet above the calcareo-silicious rock at Campbell's mills. In this portion of the coal measures, there is a great increase in the thickness of the strata, superimposed on this rock. At M'Connelsville, it is not less than 400 feet from this deposit to the tops of the hills, half a mile west of the river. At Dr. Martin's, 5 miles above, the 5th, or non-fossiliferous lime-stone, with the accompanying marls, is increased to nearly 100 feet in thickness. Four miles west of M'Connelsville, the calcareo-silicious

rock is seen in the beds of the head branches of Wolf creek, and may be traced south westerly from the bed of one stream to another, at intervals along its eastern side, from this place to Gallia county. Along this line, however, it has more the appearance of an imperfect lime-stone than that of a silicious rock.

Value and importance of the Buhr-stone.

The importance of this article in a commercial and domestic point of view, may in some measure be estimated, when it is stated, by intelligent persons who have been long engaged in the manufacture of mill-stones, that the annual amount of the manufactured article is not less than 20,000 dollars; and that it may be safely calculated at this sum, for twenty years past. When to this, is added, the money saved to mill owners, from the use of the native, instead of the foreign buhr-stone, that amount will be nearly doubled. It came into use about the year 1807; and the first pair of stones constructed of this article, on the waters of Raccoon, was by Abraham Neisby, a native of Germany. He being familiar with the foreign, or French buhr, and seeing this rock so nearly resemble that in composition and aspect, was led to make trial of it. Henry Castle, also began to make them about the same time. Soon after this, our embarrassments with Great Britain, and other commercial difficulties, led the American people to establish manufactories of various articles, heretofore altogether brought from Europe. Amongst other things, the enhanced value of the French buhr, led to the search of a material of a similar quality at home, and no doubt brought the domestic article much sooner into general use in the Western States, and especially in Ohio. The early manufactured mill-stones were made of a single piece; but these often proving to be of unequal density, and not making good flour, were abandoned, and staves constructed of separate blocks, cemented with plaster, and confined together with iron bands. Where these blocks are selected with care, by an experienced workman, the flour is said to be equal in quality to that made by the French stones.

From the year 1814 to 1820, the price of a pair of 4½ feet stones was $350, and a pair of 7 feet, sold for $500; while the foreign article sold for a still higher sum. The 4 feet stones now sell for $150. In the townships of Richland, Elk and Clinton, a large number of the inhabitants are engaged in the dressing of blocks, and in the construction of mill-stones. The buhr-rock is a mine of wealth to the inhabitants, and has contributed largely to the prosperity and independence of this whole region of country. The manufacture of mill-stones is not confined to the waters of Raccoon, but is also carried on to considerable extent in Hopewell township, Muskingum county. The quantity is apparently inexhaustible, and new quarries will be opened, at points where it is not at present looked for, and probably of a more even and compact texture than that now obtained. Few or no quarries have been yet worked by drifting under the sides of the hills, but the rock is generally procured by what is technically called "stripping," or excavating the superincumbent earth, near the top of some ridge or hill, where it is easy of access.

Quality and character of the Buhr-stone.

The characteristic excellence of the best mill-stone rock consists in its uniform texture; composed of pure quartz; free from lime and oxyde of iron, which more or less pervade the larger portion of the deposit; color

light grey; structure open and full of cells; the fragments giving a clear metalic sound, when struck with the hammer. How far this agrees in character with the French buhr, will be presently shown. Although an intensely hard rock, yet its structure is similar to that of all other stratified rocks; and it has a regular horizontal division, as well as cross fracture. The bed, or horizontal surface, is the one which contains the most cells, and is selected for the face of the mill-stone. In nearly all the quarries, the rock is found naturally broken into rectangular masses of various dimensions. As the larger portion of the quarries contains more or less of petrified shells, those the most free of foreign matters, are considered the best. While the fossils in the French rocks are all of fresh water species, those in the Raccoon buhrs are altogether of marine origin; and as this deposit is a member of the coal series, it is a much older rock than the French, which belongs to the tertiary group.

In the composition and chemical affinities of the Raccoon deposits, there is a close resemblance to those of the Paris basin, as they both abound in calcareous materials, as well as silicious. In several of the Raccoon beds, there is a stratum of lime-stone, two or more feet in thickness, both above and below the buhr-stone. In such quarries, the portion suitable for mill-stones is only from two to four feet in thickness. In others, the quartzy portion is below, and the silicious lime-stone above. The greatest thickness of the deposit in any one bed, is nine feet. In how many points of character the Paris and the Raccoon beds agree, may be seen in the following extracts from "Cuvier's Essay on the Theory of the Earth."

"Millstone without shells."

"This formation consists of iron shot clayey sand, greenish, reddish and whitish clay marl, and *millstone;* and although separated by Cuvier from the *flint and silicious limestone formation*, appears to be a member of that series. This millstone is a quartz, containing a multitude of irregular cavities, which are traversed by silicious fibres, disposed somewhat like the reticular texture in bones. These cavities are sometimes lined or filled with red ochre, clay marl, or clayey sand; and they have no communication with each other. Most of the millstone found around Paris has a red or yellowish tint; but the rarer and most esteemed varieties have a blueish shade of color. The blueish variety is the most highly prized, because it affords a whitish flour; and a millstone of this kind, six feet and a half in diameter, sells for 1200 francs. We never observe in its cavities any silicious stalactites, or crystalline quartz, and this character enables us to distinguish in hand specimens, this millstone from that in the silicious limestone: it is sometimes compact, or without cells. Another prognostic character of the millstone, is the absence of all fossil, animal, or vegetable productions, whether of fresh or salt water." "The most extensive mass of this millstone occurs in the plateau, which extends from La Ferte on the Marne, 16 leagues from Paris, nearly to Mont Miral; and here it has been quarried upwards of 400 years, for the excellent millstone it affords. The lower part of the platteau is marine limestone; the upper part, on the edges and towards the Marne, of marl and gypsum; but in the middle is an iron shot and clayey sand, which forms a bed upwards of sixty feet thick. The millstone occurs in this great bed of sand, and varies in thickness from three to five fathoms; but millstones cannot be made of every portion of the mass—a bed of rolled masses of millstone, about a foot and a half thick, lies over it—over this a thin bed

of iron shot sand, containing smaller pieces of millstone, and above this bed is one of sand from twelve to seventeen yards thick. If the stone rings when struck with a hammer, it will answer for large millstones. The bed never affords more than three millstones in the direction of its thickness. It frequently happens that the fissures allow the workmen to extract the masses in a perpendicular direction; and these are the best. These pieces are exported from France to England and America.

"*Quartz rock with shells.*"

"The second fresh water formation in the vicinity of Paris, consists of two sorts of stone—flint and silicious limestone. These substances sometimes occur independent of each other; in other instances, they are intimately mixed together." "All the varieties, both hard and soft, are traversed by empty vermicular cavities, whose walls are sometimes of a pale green color." "The essential character of this formation is, that it contains fresh water and land shells, nearly all of which belong to genera that now live in our morasses, *but no marine shells*—at least in such places as are distant from the subjacent marine formation."

From the above extracts it would seem that the Raccoon and Paris buhr stone, agree in mineral composition and mineral characters, but differ in the age of the deposits. Of course, they cannot be said to be geologically similar rocks; although the same chemical action may have attended their deposition, and origin.

Mineral contents.

No mineral substances have yet been found associated with the quartz of this deposit, except sulphate of barytes, crystallized carbonate of lime and crystals of quartz. The first is rare, the second not abundant, but the latter is found in brilliant druses, with regular faces, in some portions of the deposit, especially in Hopewell, Muskingum county. Some of these are very beautiful, and afford fine specimens for the cabinet, being occasionally tinged red or brown by some metallic oxyde. The striking similarity between these crystals and those about the lead mines of Missouri, has led to some expensive but fruitless searches for lead and copper ores; the excavations made by the aborigines having served to strengthen this belief. I have seen no other metallic minerals but those of iron, which probably percolates from the bed of ore which rests on the calcareo-silicious deposit. On the heads of Monday Creek in the N. E. corner of Green township the quartz and lime have been precipitated from the liquid which held them in solu ion, in a fine white powder, and afterwards loosely cemented. Selected portions of this rock make valuable hone-stones, and have been extensively wrought for this purpose.

1.—*General character and agricultural capacity of the calcareo-silicious region.*

As a general remark, the country is hilly, but the deposit of this rock is of so little thickness, and its inclination so gradual, that it can have but a trifling influence in modifying the face of the region over which it is spread; where it crops out on the tops of the hills and lies in broad continuous shells of quartz, it has doubtless had some effect in preserving the deposits beneath it from wasting away, and thus kept the surface of the hills, or ridges over which it lies, at their original elevation. This is

apparently the fact on "Flint Ridge," which is the most elevated tract in that region of country. Between the head waters of Salt creek and Raccoon creek, in Richland township, the same protection seems to have been given, and the ground is covered with horn-stone. But in those portions of the deposit where lime prevailed, this rock has decomposed; and wasting away, has mingled with those above and below it, forming a rich loamy soil. In an agricultural point of view, the country traversed by this deposit is equal in fertility to any of the hilly portions of the coal measures. The forest trees are of the largest size, especially the yellow poplar and chesnut; and the soil productive of all the crops common to this climate. Average thickness, 9 feet.

2.—*Iron ore—silicious quality.*

Resting on the calcareo-silicious rock, lies a thin bed of brown silicious oxyde of iron—texture porous, and filled with cavities, many of which are lined with mammillary masses of iron ore. As this deposit rests immediately on the silicious rock, it imparts to it the ferruginous matter so injurious to the color and quality of the stone. This, so far as I have observed, appears to be a regular and constant attendant on the Raccoon buhr stone, and is found scattered over the tops and hill sides of this region, where the rock has been wasted away; its silicious and ferruginous qualities, protecting it from decay. Its structure and external character are so peculiar that when once seen, it can hardly fail to be again recognized, and will serve as a guide in tracing the former course of the buhr stone, in spaces where it is now wasted away. Thickness, 6 to 8 inches.

3.—*Sand rock.*

Above the iron ore is found a thick bed of sandstone; it is rather coarse grained, chiefly silicious, but little mica, of a brown color and loose texture, easily crumbling into sand on exposure to the elements, and is the grand source from which is furnished the immense masses of sand which fill the beds of the Raccoon and its tributary branches. A fine view of its superposition on the Buhrstone may be had at a locality on section 26 in Elk township, called the "wild cat's den." It here crowns the top of the hill, affording an extensive view of the alluvions of the creek. On the Muskingum river this rock assumes a more slaty argillaceous character; but in Hocking and Perry counties it maintains its sandy texture. Its thickness may be estimated at 20 feet.

4.—*Shale and slaty clay.*

Over the sand rock is a deposit of slaty clay, of a light ash color—when exposed to the weather, or lying near the surface of the earth on hill tops, it changes into a bed of light colored clay. This is the fact at Hopewell, on Flint ridge, where it affords a material suitable for pottery, or the large crucibles used in glass furnaces. A similar clay is found a few miles west of Zanesville, near the hill tops, and applied to this use by the manufacturers of glass in that place. At Dr. Martin's, on the Muskingum river, we have a fair view of this deposit; but the shale is darker colored. At this locality, it may be estimated at fifteen feet. Only the lower portion of the deposit is composed of the fine fire clay, the upper and middle parts, being more sandy and micaceous, are fifteen feet.

5.—*Coal.*

Resting on the micaceous and slaty shale lies a deposit of slaty bituminous coal. The quality is rather poor: it burns with a ready flame when first ignited, but soon melts and runs together, obstructing the grates and the circulation of the air. The color is lighter, and specific gravity less, than common coal. A similar coal is found in the tops of the highest hills about Zanesville, nearly three feet in thickness. At Dr. Martin's, five miles above M'Connelsville, it is about twenty inches in thickness. At this place we have a good view of all the strata between the calcareo-silicious rock, and the fourth fossiliferous limestone; and the thickness of each is estimated from this locality, with reference, however, to such other as have come under my notice. The thickness of all the beds vary at different places, especially if they are distant from each other. The coal of this bed may be estimated at two feet.

6.—*Shale and argillaceous slaty sandstone.*

Over the coal is a bed of bituminous and slaty shale, containing nodular masses of argillaceous iron ore, of about ten feet in thickness; on this rests a bed of slaty sandstone, in layers of only a few inches in thickness. This stone is remarkable for its smooth beautiful bed faces, and regular thickness; it can be quarried into large flags for paving side walks, or laying the floors of cellars or kitchen hearths. This portion of the deposit is about fifteen feet in thickness.

7.—*Coal.*

Resting on the sandstone is a thin bed of clay, on which lies a deposit of coal. The quality is tolerably good. The same bed is seen in the river hills above here; below, it soon sinks under the bed of the Muskingum. Thickness, 2 feet.

8.—*Shale and slate clay.*

Over the coal lies a deposit of bituminous shale and slate clay. In this member of the series, no iron ore was observed. Thickness, ten feet.

9.—*Compact sand rock.*

Over the shale lies a thick deposit of compact sand stone. The texture is rather coarse and silicious where it has tumbled out of the hill side, by the undermining action of the water of a small branch which puts into the Muskingum, not far from the outlet of Island run, it lies in large masses. At this spot I did not observe any stems or coats of fossil coal plants; but in Gallia, a little east of the village of Vinton, a rock, whose geological position and structure is similar, contains fine casts of "calamites cannoformis and other coal plants." Thickness, 25 feet.

10.—*Slaty shale.*

Over the sand rock we find a thick deposit of shale and slate clay, on which is a thin bed of coal, of only a few inches; at this locality the coal has given a dark tinge to the lower layer of lime-stone, which rests upon it. The same effect is seen on the lime rock, in the hill near the town of Vinton, in Gallia county. This heavy bed of shale, with the sand rock

above, and lime below where it crops out on the surface, and they become mingled together, forms a rich and durable soil. Thickness, about 30 feet.

11.—*Lime rock.*

Resting on the shale, which in some places approaches a blue argillaceous sand stone, we find the upper fossiliferous limestone. At this locality, in Bloom township, it lies at an elevation of 100 feet above the base of the hills, while at M'Connelsville, five miles below, it is found in the bed of the river, and has been recently penetrated in excavating the lock-pit at that place. From Bloom township, it can be traced on to the hills north and west of here, especially in the dividing ridges of Sunday and Moxahala creeks. It lies in regular beds or layers, of eight or ten inches to more than a foot in thickness. In some places, especially on Sharp's fork of Federal creek, in range 12, township 8, section 31, these layers are separated by deposits of calcareous shale, increasing the thickness of the deposit to 12 or 15 feet. In other localities the shale is wasting, or has been wasted away by the action of water; and the lime rock is reduced to 6 or 8 feet in thickness. It is every where filled with fossil shells, in some instances so abundant as to form the greater portion of the rock, cemented together by argillaceous matter. For this reason, this deposit may be known and recognized at remote and distant points of the coal measures, which it is much more difficult to do with the non-fossiliferous shales and sandstones. This character makes such beds valuable to the geologist, in locating other deposits, either superimposed or subordinate to these strongly marked beds. Amongst the fossils of this deposit we see joints of encrini and terebratulæ, generally very small; producti, gryphea, and few or no spiriferi. In place of which we find many equivalved bivalves, and several new genera of turbinated univalves, not found in the lower or older limestones. In some localities, especially near the outer margin of this rock, the lower layer of the deposit is made up of fragments of limestone, forming a calcareous conglomerate. It may be seen on a hill three miles south of Athens; also, in Morgan township, in Gallia; and I have seen the same peculiar rock on Wills' creek, in the southwest corner of Guernsey county. It seems to have been broken up by the action of water, as a recently formed rock might be by the waves on a beach, and has apparently been brought about by a similar cause to that which acted on the silicious conglomerate, in Richland township, and afterwards covered by a fresh deposit made in quiet water. These fragments are in some places not larger than a pea, in others coarser; but all have been rounded by attrition—were it sufficiently hard to receive and retain a polish, some portions would make a handsome brecciated marble; but this quality it lacks from the formation being sedimentary and earthy. Soon after the era of this deposit, a change seems to have taken place in this part of the ocean, either from the raising up of the bottom, or from the draining off of the waters, rendering it too shallow for the existence of the testaceous animals which then peopled it. In the series of rocks above this, amounting to more than 400 feet, I have as yet been unable to find any other than fresh water shells or the stems and impressions of the foliage of coal plants, which probably grew either near estuaries, or amidst fresh water lakes. Further examinations will, however, most probably bring to light, additional evidence of the longer continuance of the oceanic waters over this portion of the valley.

Range and extent.

The upper fossiliferous lime-rock is at this place, (Sharp's fork of Federal creek,) fifteen feet in thickness, and lies about 80 or 100 feet below a bed of coal, which I have many reasons for believing to be the same deposit as the Pomeroy bed, on the Ohio river, in Meigs county. The position of the limestone is conformable to that of the superincumbent beds, and as we travel westerly, rises gradually on to the tops of the ridges of Sunday creek hills. The same rock is seen on the hill in the town of Athens, and at various other places, west and south of that locality.

From Athens county, this deposit may be traced across the west end of Meigs county, into Gallia. Here, in the township of Morgan, it is seen in the heads of Campaign creek, lying in a thick bed, filled with the usual fossils. The inferior layer, from its resting on coal, is nearly black. From the heads of Campaign, it is traced into Springfield, and down Chickamoga creek, to within a few miles of Gallipolis, when it sinks below the bed of the creek. At the mouth of Lime-stone run, eight miles north of this, it lies at the base of the hills. Several kilns of this lime-stone have been burnt here, and on Chickamoga. On Leading creek, still further north, in Meigs county, it sinks below the bed of the stream, near the upper salt well. As the dip of the strata is east south east, and the river Ohio here, for many miles, pursues nearly a north and south course, the seeming difficulty of its disappearance near the Ohio for so long a distance, is explained, as the direction of the Ohio is in the line of bearing and across the line of dip.

The upper fossiliferous lime-rock, can be traced across the counties of Morgan, Athens, Meigs, and a part of Gallia, with an average width of 10 or 15 miles from its western outcrop, to its disappearance below the beds of the streams east. The average thickness of this deposit may be estimated at 8 feet.

No. 12.—*Slate Clay, Shales, and thin slaty Sand-rock.*

In situations where the original strata have been but little disturbed, we find a bed of pale blue slate clay, resting on the lime-stone, which, when exposed to the weather, falls into a blue plastic clay. Above this is a shale, containing nodular masses of argillaceous iron ore, ending in slaty sand-stone. A fine view of this portion of the series may be obtained on Sharp's and Cutler's forks of Federal creek, in the township of Ames, Athens county. Considerable quantities of iron ore are imbedded in this shale, which makes its appearance at several places in Meigs and Gallia counties. It is also well developed in the hills near Dr. Martin's, in Morgan county. At some localities, the ore is apparently so abundant as to be valuable for manufacturing purposes, especially on Federal creek. The whole series of slates and shales are at least eighty feet in thickness.

13.—*Lime-stone, hard and compact—containing a portion of Iron Ore, and Sulphuret, sufficient to coat over the surface with a buff colored crust when exposed to the weather.*

This bed is more fully developed in Marion township, Athens county, on section 24, town 7, and range 12, than at any other spot which I examined. This locality is near Mr. Patterson's, on one of the head branches of Federal creek. It is a regular attendant of the Pomeroy coal bed, which lies over it. In some places it is very thin, and lies in amorphous

or nodular masses, disseminated in the compact, carbonaceous slate clay which lies under the coal. No fossil shells were noticed. In Marion, this rock is 4 feet in thickness; in other places not more than a foot; average 2 feet.

14.—*Slate Clay—compact and carbonaceous—dark colored.*

It is of a quality suitable for the manufacture of fire bricks, and receives its dark tinge from the coal which rests upon it. The thickness varies at different places, but averages about 3 feet.

15.—*Coal—black and bituminous.*

For distinction, and as a mark of respect to the enterprising individual who first promoted the opening and extensive working of this valuable bed, at the village of Pomeroy, on the Ohio river, in Meigs county; this deposit may be denominated "the Pomeroy coal bed."

Range and extent.

It may be traced from the south side of Morgan county, across Athens and Meigs, to the Ohio river. North of the head of Federal creek, the coal becomes thin, but can probably be followed and recognized to the vicinity of M'Connelsville. It is the most fully developed on the waters of Federal creek, the westerly branches of Shade river, on Leading creek, and on the Ohio river; pursuing in the line of its bearing, or "strike," rather a north easterly and south westerly course, with a pretty regular dip to the east and south east, except in the high lands a little south of the town of Athens, where the sand-rocks are greatly increased in thickness, and the regularity of the dip broken in upon, either from faults, or some upheaving force from below. From present appearances, this high ground has diverted the course of the Hockhocking river, and turned it easterly from its direct route to the Ohio. The head branches of Shade river take their rise in this elevated ridge, and flow south easterly to join the Ohio about 12 miles below the mouth of the Hockhocking, in a very broken and hilly region. If we look on the map of this State, it will be seen that all the streams which rise within, or across the western side of the coal measures take a south easterly direction, which, it may be suggested, is probably caused by the east and south easterly dip of the rock strata. The Ohio river, after receiving the accumulated waters of the whole basin, flows south westerly in the most depressed portion of the coal measures, cutting its channel across the strata, where it found the least resistance.

From the extensive boundary of "the Pomeroy coal bed," on both banks of the Ohio river, giving it commanding and peculiar facilities for market, it may be deemed one of the most important beds on the west side of the coal deposits. For these reasons, it will demand a more particular history of its extent and appearance at different localities.

Commencing, then, in Addison township, a little below the mouth of Kuyger creek, in Gallia county, we find a bed of coal near the top of the river hill, at an elevation of 150 feet above the bed of the Ohio. This spot is about 14 miles below the point where the Pomeroy coal dips under the surface of the river, in Salisbury township, Meigs county, and is also about seven longitudinal miles west. The coal here is about eighteen inches thick, with a roof of bituminous shale of three feet, and a coarse

sand-rock above. Five miles above Kuyger, the same coal bed is seen in the hills at the height of 70 feet above the bottoms, and has increased to four feet in thickness. At this locality, several masses of the lime-stone, which lies under the coal, are seen scattered on the slope of the hill below. At the mouth of Leading creek, two or three miles higher up the river, the thickness has increased to nearly 5 feet, and the elevation lessened to about 40 feet above the bottoms. Three or four miles above this, at the village of Pomeroy, the river makes a bend to the south east, and the coal in its eastern dip, gradually approaches the water and sinks below the surface in range 13, town 2, and section 35, at a point a little north of due east from the mouth of Leading creek, and distant, on a westerly line, only about 5 miles, but as much as eighty by the course of the river, where it disappears, and for several miles below, the coal is fully 5 feet in thickness. Following the same bed over on to Leading creek, 7 miles from its mouth, in a north westerly direction from Pomeroy, we there find the coal at an elevation of 150 feet above the bed of the creek, and increased in thickness to fully 6 feet; showing the regular rise of the rock strata, in a west and south west direction, and a dip to the east. The sand rock here rests on the coal, without any intermediate shale, which may account for its greater thickness than at the village of Pomeroy, where there is a deposit of several feet of shale over the coal. In a west and north west direction, the coal may be traced on to the heads of Leading and Kuyger creeks, and runs out in Gallia and south west part of Athens county, becoming gradually thinner, until it mingled with the soil on the surface. Returning to the mouth of Carr's run, and pursuing the course of the Pomeroy coal bed northerly, we find it in the bed of this run about a mile north of the village; and as we ascend on to the hills, we rise above the coal, which disappears under the ridge that divides the waters of Carr's run from those of Thomas's fork of Leading creek. On descending this ridge, the coal appears a little above the bed of the stream, on section 16, more than 3 miles from the river. It is here 5 feet in thickness, lying under the same coarse sand-rock, with a bed of shale above the coal. Still traveling northerly, we rise on to the dividing ridges between the waters of Leading creek and Shade river; on descending which, two miles farther north, in range 13, town 3, and section 9, on the land of Mr. Barton, it is seen in the bed of the west branch of Shade. The coal here is 4 feet thick, resting on blue clay, with a thin bed of compact slate clay over the coal; lying on which is a deposite of bituminous shale, six feet in thickness, and of so rich a quality as to burn freely. Above this, the coarse sand-rock is seen in a bed of 50 or more feet in thickness. In the clay over the coal, are a few scattered masses of nodular lime-stone, highly charged with sulphuret of iron. The coal is here of a good quality, and breaks into acute angled fragments, similar to that in the Pomeroy beds on the river. Near the north line of the county of Meigs, on the farm of Mr. Storer, the coal is seen lying in the bed of a branch, and about ten feet above it, there is a thin vein of coal, with slate and shale interposed between them, and similar masses of nodular lime-stone, to those seen at Barton's bed. Above them lies the accompanying bed of coarse, loose sand-stone in heavy masses. In traveling northerly, into Athens county, we leave the bed of the main stream of Shade, and pass over elevated ground for more than a mile, and descend on to Pratt's fork, a westerly tributary, in Lodi township. A mile or more west of the road, the coal is found increased in thickness, and gradually rising on to a higher level. From this point, it was traced across

Lodi township, into Canaan, to within 5 or 6 miles of the town of Athens. Here the coarse sand-rock is greatly increased in thickness, and the country rises into lofty ridges. This locality is on the west side of town 5, range 13, and also on the westerly side of ' the Pomeroy coal bed," the general range of bearing of which is north easterly, or east of north. The beds on the Ohio, are in the same range of townships, and distant in a direct line, about 18 miles. A little above the mouth of Federal creek, which is about ten miles from this place, and on a line somewhat north of a due east course, the coal is said to be 5 feet thick, and sinks below the bed of the stream. The dip is in that direction, and at 20 feet per mile, would give the coal at this locality an elevation of 200 feet above the bed of the Hockhocking, at the mouth of that creek. It is here reduced in thickness to between 3 and 4 feet. In the town of Athens, 4 or 5 miles north west, we find the upper bed of fossiliferous lime-rock, lying on the top of a hill in the town of Athens, at an elevation of probably 180 feet above the bed of the Hockhocking. Two miles south east of Athens, across the river, the country rises into a lofty ridge, at least 300 feet above that stream. This very high ground has apparently turned the course of the river and caused it to flow nearly due east to the mouth of Federal creek; below which its course is more southerly to the Ohio. From the point where the coal is last seen above the mouth of Federal, it can be traced all the way up the creek into Marion township, in range 12, and gradually rising from the bed of the creek, because the direction pursued is north easterly. From the forks of this creek upward, I have examined it at several points, and find the upper fossiliferous lime-rock lying about 80 or 100 feet below the coal, especially on section 24, in town 7, range 12. Here we find the coal and shales arranged in the following order: Coal, 4 feet, resting on the compact slate clay; over it, a bed of ash colored, compact shale, 1 foot; bituminous shale, 18 inches, so rich as to burn; thin coal, 18 inches, on which rests a coarse grained sand-rock, very thick, and bearing a close resemblance to the order observed at Barton's, in Meigs county. East of this place, the coal dips below the beds of the streams, and is covered by the deposits which are to be subsequently named. On a line, this locality is north and a little east, more than 30 miles from the village of Pomeroy. The average width of "the Pomeroy coal bed," from its outcrop on the hills westerly, to its disappearance under the beds of the streams easterly, may be estimated at 10 or 12 miles. Its average thickness, 5 feet.

Fossils which accompany "the Pomeroy Coal bed."

In the shale beds, which generally form the roof of this coal, we find innumerable casts and impressions of the foliage and stems of various coal plants, of which have been collected more than twenty species.—Amongst them may be recognized of the *Equisetaceæ*, the *Calamites* and *Equisetum*—of *Filices*, the *Sphenopteris*, *Glossopteris Neuropteris*, *Pecopteris*, &c. The Lycopodiaceæ, such as Lepidodendron, Sigillaria, &c. are rare in this deposit, but are common in the earlier formed beds.—The most interesting feature of the rocks connected with this coal, is the great abundance of fossilized stems and branches of trees, that are found to accompany the coarse sand-rocks which lie over the coal, in several localities which have been visited. So few quarries, or excavations, have been yet opened in this rock, that we can only discover them in beds of streams, or situations where the rock has crumbled away by natural causes.

Fragments of fossilized trees are seen in several of the branches of Federal creek; the beds of Campaign and Leading creek, but more abundantly in the heads of Shade river, township of Lodi, Athens county. The extreme northerly branch of this river, rises in that high ridge of land south of Athens, before noticed, and not more than a mile from the Hockhocking river. About 3 miles south, this branch becomes a rivulet of ten or twelve feet in width. In the bed of this rivulet, and also in one which heads with it, and puts into the Hockhocking, are found numerous tabular, oval masses of silicious composition. They are from 4 to 10 inches in thickness, and from 2 to 3 feet in diameter, with others that are smaller. One of the sides is almost invariably concave, or depressed in the center, and the opposite one plane or slightly convex. They are evidently petrifactions of some vegetable substance, as the traces of the fibrous structure is very apparent in all the specimens. The form of these masses very much resembles that of the base of the *Stigmaria ficoides*, with the branches all broken off. They are composed of the hardest silicious matter, of a redish, grey color. Fragments were broken and brought away, and arrangements made for procuring a perfect specimen. Isolated masses are scattered along the bed of the branch for more than a mile, the bottom of which is composed of a slaty sand-rock, deposited in thin layers, highly inclined, and of slight coherence. No specimens were found in place, but they were doubtless originally imbedded in a coarse sand-rock, which lies over the coal. This opinion is strengthened by the fact that portions of the trunks and roots of the fossil trees found lower down the branch, are often ploughed up in the fields, on the hill sides, 50 or 80 feet above the bed. A few miles lower down, and six and a half miles from Athens, the beds of several small streams, all tributaries of Shade, and rising over a space of 8 or 10 square miles of surface, are found strewed with the segments of trunks of fossil trees, varying in diameter from a few inches to 18 or 20 inches. The larger sections are generally perforated by a circular opening near the center, from 1 to 4 or 5 inches in diameter. The regular shape of the pieces, resembling transverse sections of a log of wood, seems to be the result of a peculiar mineral organization, disposing the fragments to assume a cubic form, had the exterior of the fossil been square instead of circular. The ligneous structure of the original tree was coarse, very distinct, and highly vascular; it is now replaced by silex, in many specimens beautifully agatized.—Some of the pieces are filled with perforations, the size of a quill, and larger, which seem to have been made by a worm. This, most probably, was done by an ancient *Teredo*, after the trees were torn up, and floated down some river to the ocean. Fragments, three or four feet in length, are the longest yet discovered. The quantity of specimens is so great, that we might be led to suppose a whole forest had originally been entombed in this place, covered with beds of a highly silicious quality, and consolidated into sand-rock. These rocks being less dense and compact than the fossilized wood, have, in the course of ages, crumbled into soil, and left the imbedded trees to fall out in fragments, and gradually wash down the slopes of the hills into the beds of the streams, where they are now found. As the age of this rock is long anterior to the Tertiary, these fossil remains are not likely to be allied to any living species of tree which now vegetates in the forests of Ohio. It most probably belongs to the tribe of Gymnosperma, of Lindley; a race of plants whose seeds are naked or formed without a pericarpium, or envelope. From the great vascularity of the trunk, and the fact of the fragments being almost entirely com-

posed of the shafts of the trees, with few or no branches, we are led to conclude, they may be attached to the order Cycadea, the woody fibre of which is very similar in structure to the coniferae, or pine race, and which are only found in some of the more recent coal deposits. In the final report, we hope to give drawings of these interesting fossils, and satisfactory descriptions of the family to which they belong.

16.—*Iron Ore.*

Imbedded in the shale, which lies over the Pomeroy coal bed, at several localities, we find a deposit of fragmentary, argillaceous iron ore. It resembles bog ore, considerably, but is more compact and heavy than that variety of ore. It is generally coated over with yellow oxyde, and appears to be composed of cemented fragments. It is considerably abundant at the locality in Marian township, and also on Sharps fork, in Bern and Homer townships, Athens county. The thickest and most valuable bed of this variety of ore, and which, from it position, appears to be a continuation of the same deposit, lies near the top of the ridges, between the head branches of Kuyger and Campaign creeks, in the township of Cheshire, Gallia county, on sections No. 19, 20 and 25. It has as yet been but partially opened, and is about two feet in thickness. The ore is an argillaceous oxyde, breaking easily into cubic fragments, coated with yellow ochre. Should further search prove the ore to be extensively spread over this region, and to be of good quality, its proximity to the Ohio river, not more than four miles, will add much to its value; a deposite of coarse sand-rock lies over the ore, which in many places has wasted away, leaving the bed covered only with earth, ——; ore, 2 feet.

17.—*Sand Rock—coarse grained, friable Sand Stone.*

This rock rests upon the shale over the coal, and, in some localities, immediately on the coal itself; where this is the case, the sulphurets, which accompany the coal, seem to have penetrated the rock for some feet, covering the outer layers of sand with minute crystals of sulphate of iron, or alumine; and in shaded, damp situations, rendering the rock tender, and disposed to exfoliate in thin sheets from the vertical face of the cliff. This is strikingly the fact on section 24, township 7, and range 12. In other situations, the rock is firmer and compact. Wherever this rock has been noticed, it lies in thick heavy masses, especially on the heads of Shade river, in Lodi, where it attains the thickness of 80 or 100 feet; at other places, it is usually from 40 to 50 feet, especially between Lodi and the Ohio river. The upper part of this deposit might be divided into one or two more sections, especially a coarse-grained siliceous sand, without any mica, a layer of which, at the village of Pomeroy, has been worked into excellent drip, or filtering stones. At Dr. Martin's, on the Muskingum river, we find a similar rock, lying over a thin bed of coal of 18 inches, or 2 feet, whose position in the series corresponds to this, and is probably the same; the upper portions of which, above the coarse sand, are in thin layers, containing considerable mica. It is a difficult task to trace a single deposit of shale or sand-stone for many miles—the outcropping edges of the strata crumbling down into soil, and often interrupted by ridges and hills, which contain other superimposed rocks: where peculiar fossils are imbedded in them, the recognition is easy; but, in general, a stratum can be only determined by its *connection* with others,

and its *position* between certain strongly marked deposits. Beds of much volume seldom change their *character* within moderate distances, but oftentimes their *thickness*. This member of the series contains the fossil trees described above, and may be estimated at 50 feet.

Agricultural character of the region traversed by the Pomeroy Coal Series.

The central and western portions of Meigs County, and the southern of Athens, are watered by Shade river and Leading creek. The country is generally hilly and broken nearer the larger water courses, but affords extensive tracts of fine rich farming lands, especially in the heads of the streams. The whole was originally covered with a heavy growth of forest trees. The surface of the earth being composed of the out-cropping edges of the shales, sandstone and lime, crumbled down and mingled with the decaying vegetable matter of the forests, affords a soil that is rich, productive, and durable. The porous sand-rocks, absorb and retain the rain-water, so as to furnish lasting springs and streams, sufficient for the wants of the inhabitants during the dryest seasons. Those distressing, and often ruinous droughts, so common to calcareous formations, are here unknown. On the middle branches of Federal creek, and the high lands between those branches and Sunday creek, the surface is broken, by the wasting action of water, into long, elevated hills, crowned with narrow ridges, which, in some places, for miles in extent, are barely wide enough for a road. These narrow spines are generally conformable to the course of the streams, and rise to the height of 50 feet. At the base of these ridges is a flat, or terrace, of a number of rods in width, which gradually slopes down to the creeks, affording fine farming lands. The singular form of these ridges is attributable to the lime-rock, of which they are composed, and which here overlies the sand rocks and shales of the Pomeroy coal formation. Its more compact texture has preserved it, while the softer shales and sand stones have given way to the water and atmospheric influences. The non-fossiliferous, or upper lime-rock, here lies on the tops of the narrow ridges, and often forms a natural pavement for considerable distances. In other spots it is broken into fragments, intermingled with which are seen nodules of the red oxyde of iron, of a color nearly as brilliant as vermillion. Although the country on these streams is hilly and broken, yet the "Federal Creek Hills" are noted for their fertility, and clothed with sugar-trees and beach to their tops. The whole region is productive in grain and grass. On Leading creek, some of the townships are distinguished for their fine meadows; and no part of Ohio affords more desirable and healthy ranges, for flocks of sheep and herds of cattle, than those portions traversed by the Pomeroy coal beds.

18.—*Reddish Calcareous Shale.*

Resting on the upper portion of the slaty sand-rock, noted in section 17, is a thick bed of reddish brown calcareo-argillaceous shale, intermixed with layers of loose yellowish lime-stone, which easily crumbles on exposure to the weather. This portion of the series was taken in the Muskingum river hills, in Bloom township, Morgan county, and near Dr. Martin's. A channel has been cut through the whole deposit in search of coal. Its thickness is about 50 feet.

19.—*Bluish Clay Shale.*

Lying on the lime and reddish shales, we find a deposit of clayey shale, blue or dove-colored. It is free of mica or grit. Under the shale is a thin layer of coal, of only an inch in thickness. Shale, 8 feet.

20.—*Lime Rock.*

This rock is hard and tough, not breaking freely; argillaceous quality; color, dirty gray. It contains no fossils, and is the lower member of the non-fossiliferous limestone deposit—6 feet.

21.—*Compact Slate Clay.*

Resting on the limestone, is a bed of dark-colored shale; where exposed to the weather it falls into a tough plastic clay, and probably suitable for the construction of fire bricks—3 feet.

22.—*Coal—bituminous and slaty.*

This deposit is so intimately associated with the non-fossiliferous limestone, that it may be called the "limestone coal." It is quite an extensive bed, and may be traced wherever this lime rock is found.

Range and extent.

Beginning with this coal on the hills two miles east of M'Connelsville, we find it there of a fine quality and four feet in thickness. It has been opened but a short time, and supplies some of the best coal for domestic use, that is found in that vicinity. The elevation of this bed is estimated at 250 feet above the surface of the river. Near the town, the strata containing the coal have been washed and wasted away by the denudating action of the water in seeking its present channel. It is the same on the west side, where the coal and limestone are distant at least half a mile. From this point, the coal can be traced down the river to Meigs creek, where it lies at a much less elevation, and at the mouth of Wolf creek in Waterford, Washington county, it has sunk to the bed of the Muskingum, This point is about 15 miles southeasterly from M'Connelsville, but not much over 12 miles of east longitude, which will give a dip of about 20 feet to the mile. East and northeast of this town, the coal is found in rather increased thickness, on the waters of Meigs, Olive, Green, and Duck creeks, dipping east and southeast, from their heads to their outlets. West of the Muskingum river, we find the limestone, in the southwest corner of Roxbury township, in the banks of Coal run, a southerly branch of Wolf creek: here the coal is increased to 5 feet in thickness. From thence it is spread out south on to the waters of Little Hocking. On the westerly branches of this stream, in Decatur township, it is seen in beds of three or four feet in thickness, in company with the limestone. On the Ohio river it has become quite thin, and lies near the base of the hills; westerly it appears to run out on the hills of Federal creek. A few miles below the mouth of Wolf creek, it is found in the bed of the Muskingum, and has been worked for many years, during low stages of the water. At Coal run it has been followed under the base of the hill, for several hundred feet, by a drift, the floor of which is only a few feet above the river: here the coal is divided by a seam of slate, a foot thick, above the

slate is a foot of coal, below it, nearly four feet. At Bear creek, ten miles from the mouth of the river, is the lowest point where coal has been dug; but it may probably be found some lower before it dips beneath the bed of the stream. The average thickness of coal, may be estimated at four feet.

23—Bituminous Shale, and slaty Sandstone.

Over the coal is a deposit of black bituminous shale, changing to an ash colored shale of about eight feet in thickness; on this rests a deposit or layer of hard blue sandstone, eight or ten inches thick, superimposed on which are layers of slaty sandstone, of an argillaceous texture, containing some mica. The upper layer is quite calcareous, the whole amounting to 12 feet. These beds of shale and sandstone, wherever I have seen them vary some, however, in thickness, being at certain localities only a few feet. Shale and slaty sandstone, 18 feet.

24.—Lime rock—non-fossiliferous.

This rock constitutes the most voluminous deposit of limestone, that is connected with the coal measures of the valley of the Muskingum. It lies in stratified beds, varying in thickness from one to three or four feet. The *upper and middle* portions of the deposit, are pale yellowish, or buff colored, gray, or dark blue. In many places, the rocky layers are separated by beds of *calcareous shales*, which are three or four feet in thickness. The shale beds vary in color from pale blue to ash, and dark or light brown; the whole series is from 40 to 50 feet in thickness; and in some places, especially a few miles above M'Connelsville, it is much more. The buff colored layers, break naturally, into prismatic fragments, and readily decompose on exposure to the weather. The blue colored deposits are more compact, and break into rhombic masses, with rather conchoidal surfaces; many portions contain seams of colored spar. The lower member of the deposit, where it approaches nearer to the coal than usual, is very dark colored, and then frequently contains imbedded crystals of brass colored sulphuret of iron. These are generally cubes, and where the stone is very dark, their bright yellow faces make a striking contrast with the dark hue of the rock; some of the lower beds will not slake when burnt, and may, probably, furnish hydraulic lime. This rock is readily distinguished from the deposits of lime found lower in the series, from the fact of its containing *no imbedded fossil shells;* and may be denominated *non-fossiliferous lime-rock.* The beds of stone marl, found in Washington, Athens, Meigs, and Gallia counties, appear to be associated with this limestone, as they have not yet been found in the hills beyond its western and northern termination; wherever it abounds the ridges are covered with a rich soil to their summits. The bed of the middle, or main branch of Wolf creek, affords a fine view of this rock, where it has cut a channel through the whole thickness of these deposites; and for nine miles above its mouth, the bed of the stream is formed of limestone. One mile east of M'Connelsville, and fifteen miles northwest of the mouth of this creek, the lime-rock lies at an elevation of 250 feet above the bed of the Muskingum. Four miles below the mouth, at Coal run, the bed of the river is a little below the lime-rock, while at the mouth, the water in falling over a mill dam has cut through the strata down to the coal. From this point, it is seen to within a few miles of the Ohio, near the base of the hills, and only a few feet above the

water; varying in this respect, according to the course of the river. The main dip in the rock being from the west to the east, and the course of the river for the last twelve miles, nearly north and south, or on the line of bearing, will explain the difference in the amount of dip between the two places. The last place where the rock is seen in the bed of the river, is at Devall's ripple, five miles above the mouth. East of the Muskingum, the non-fossiliferous lime may be traced from Meigs creek, over on to Olive, Green, and Duck creeks, and Little Muskingum, in Morgan and Monroe counties, dipping down south and east, from near the tops of the hills to the Ohio river. The same bed of coal accompanies the lime, and increases to four and a half or five feet in the heads of Duck creek, in the corner of Munroe county. On the west side of the Muskingum, this deposit can be traced on to the heads and middle branches of Wolf and Federal creeks, in Morgan and Athens counties, to near the waters of Sunday creek, when the fourth fossiliferous lime rock comes to the surface and bassets out on the hill tops west of it. South, it continues down the waters of the Hockhocking, to within a few miles of its mouth, when it dips below the beds of the streams. It is also seen in the western branches of Little Hockhocking, gradually sinking as it approaches the Ohio river. The whole deposit may be estimated at 40 feet.

25.—*Calcareo-argillaceous Shales and Micaceous Sandstone.*

Resting on the lime is a bed of schistose sandstone, of a few feet in thickness, varying in this respect at different places; above which, are deposits of various colored clay-marls. They are the fullest developed on the West branch of the little Hockhocking, on Sec. No. 1, T. 6, R. 11, at Fairchild's mill, in Decatur township, Washington county. This locality is about four miles by land, and six by the course of the stream, from the Ohio river, which, in high floods, backs the water to near the top of the deposits. Here the marl is seen in three distinct beds, of about five feet each. The upper one is of a light ash, or grey color; the middle a dark-brown, and the lower a deep verdigris green. The upper one contains the largest share of calcareous matter, and will afford a valuable article of manure, in the cultivation of the adjacent uplands, which generally hold a large proportion of sand in their composition. The brown will also be valuable, as it falls rapidly into a fine pulverulent earth, on exposure to the air. The dark green, when wet and broken up, passes into a fine pale-blue clay, and will afford a valuable material in the manufacture of pottery.

Range and Extent.

North of this locality, the marl deposits extend to the Muskingum river, across the townships of Barlow, Wesley, Watertown and Waterford, and westerly to Athens county; southerly, the red shales extend as low as Gallia, forming a series of deposits, intermingled with the other rocks, which lie over the main coal deposits. Similar beds are found in Wood county, Virginia, and can be traced on both banks of the Ohio, from the mouth of Guyandot to Fishing creek, and for 20, or more, miles from the river; varying, in this respect, according to the course of the stream. It appears to be confined to the central portions of the basin, and to have been amongst the most recent, or last, deposited strata of that numerous series connected with the coal measures and muriatiferous rocks. In its composition, there is a large share of argillaceous matter, colored with

iron; while some of the beds are so highly charged with lime, as to be properly classed with stone marls. Some of the ash-colored deposits contain fragments of shells, as I am informed by Mr. Jesse Lawton, of Barlow, who has applied it as a manure to thin uplands, with great success. The analysis will be given, with other articles, in the progress of the work. Average thickness, 20 feet.

Agricultural character of the region traversed by the non-fossiliferous Limestone and Marls, West of the Muskingum River.

As a general remark, the whole of this region may be said to be hilly and broken; and yet it contains extensive tracts of level, or very moderately undulating lands, of a rich quality, and producing fine crops of grain and grass. The uplands, where uncultivated, are clothed with a heavy growth of forest trees, chiefly of the various species of oak and hickory, with occasional groves and solitary trees of the yellow pine. This species of tree seems, at some remote period, to have held a much higher station amidst its fellows of the forest, than it now does. Extensive tracts, on which the growth at present is altogether composed of other families, are literally strewed with the knots and hearts of the pine, from which, in many places, tar is manufactured in sufficient quantity to pay the first cost of the land. At this day, its growth is almost wholly restricted to the chocolate-colored soils embraced in the range of the red shales. It has been remarked, that a soil congenial to the yellow pine, is one of the most productive of wheat, being generally more calcareo-argillaceous than sandy; where the marl crops out on the sides of hills, in cultivated fields, it is discovered, not only by the reddish color of the soil, but also by the deep rich green and luxuriant growth of the Indian corn, wheat and grass. West of Washington county, between the waters of Wolf and Federal creeks, the coarse sand-rocks which lie over the limestone and marls, rise into lofty ridges, and the character of the soil changes, becoming more sandy and loamy, with a forest growth of yellow oak, chesnut and poplar. This variety of soil has a decided influence on the temperature of the atmosphere; ameliorating and warming it in the spring and autumn, and thereby protecting the blossoms of fruit trees and tender vegetables from the ill effects of untimely frosts, a matter of no small importance to an agricultural people. It may be satisfactorily accounted for, in the greater facility with which an arenaceous soil absorbs caloric by day and radiates it by night, than that of an argillaceous quality. It is finely illustrated in the tobacco plant, where this delicate vegetable may be safely left without cutting, one or two weeks later in autumn, than on soils of a clayey quality. Such soils, on elevated grounds, are also nicely adapted to the culture of fruit trees; and orchards of apples and peaches, planted on these ridges, not only produce larger and finer flavored fruit, but also escape many late frosts in the spring, which entirely destroy the blossoms and embryo germs of trees planted in the valleys between the hills. These remarks I have seen verified in my reconnoissance of the counties of Perry, Morgan and Athens, amongst the ridges in the heads of Moxahala, Sunday, Federal and Wolf creeks. As we approach the eastern branch of Federal creek, the country rises into long lofty ridges, based on a loose open sand-rock, which readily disintegrating into a light sandy loam, affords a soil highly congenial to the chestnut and chestnut-oak, which delight in lofty and dry situations. In all countries, and not less so in the hilly portions of Ohio, the character of the soil may be known, from the

quality of the rocks on which that soil is based; where argillaceous sand-rock and shales abound, the soils are of a clayey character; where lime-rocks prevail, the soil will be of a dark color, loamy texture and very fertile, supporting a growth of forest trees on the sides and tops of the highest hills, similar in species to those of the richest alluvions, while a thin, fissile, slaty sand-stone, so hard in its texture, that no influence of rain or frosts can cause it to disintegrate, affords a soil on which nothing can grow but stinted scrub-oaks and the native vine of the hills: such is the character of the soil in some of the highest ridges in the southwest corner of Athens county, while in the northeast portion, on the heads of this creek, the hills, although lofty, are clothed with heavy forest trees, and coated with a rich, black calcareous soil. For this advantage, they are indebted to the lime-rock which crowns their summits, and imparts a fertility to the creek alluvions, fully equal to those of the Ohio river. As we approach the Hockhocking river, the ridges and hills become still more elevated, not from any actual rise in the surface of the country, but from the beds of the streams being sunk deeper. This peculiarity is common to all the region embraced in the coal measures, and of itself is a convincing proof that the surface was, at some remote period, nearly a uniform and level country. The bottom lands on the Ohio and Muskingum rivers, which skirt the district on the southeast, are noted for their fertility, and afford some of the most productive farms in the State.

Fossil fresh water Shells.—Bed of ancient Lake.

On Mr. Lawton's farm, in Barlow township, Washington county, in the midst of the marl region, is a locality of fossil fresh water shells, of the genus unio. They are imbedded in coarse sand or gravel, cemented by ferruginous matter. The specimens are casts, replaced by an argillaceous oxide of iron. The spot in which they are found, has once evidently been the bed of an ancient lake or pond. It is now a beautiful valley of a mile or more in width, by four miles in length, surrounded by low hills. On the south side, a small branch drains the superfluous water into the Little Hockhocking. In digging wells for domestic use, in this tract, beds of sand, gravel and plastic clay, are passed to the depth of 30 feet, containing imbedded branches of trees, leaves and fragments of wood, of recent and living species. Similar valleys and levels are found in the uplands of the western part of the county, lying between the head waters of the creeks, and are a kind of table land. From the frequency of these flat lands between the head waters of the Little Hockhocking and the south branch of Wolf creek, it is quite possible that, at some remote period, the waters of Wolf creek were discharged into the Ohio river, instead of the Muskingum. This opinion is strengthened from the fact, that the head branches of the south fork now rise within two miles of the Ohio, and run northerly, parallel with, and opposite to, the course of the Muskingum for 12 miles, and join that river, 20 miles from its mouth. The remains of its ancient beds would form pools and ponds of standing water, furnishing fit residences for the fresh water shells, whose fossil remains are now found there. Great changes have, evidently, been made in the direction of all our water courses, before they found their present levels.

Fossil contents of the red Shale.

The fossils found in the calcareous shales, are generally of vegetable origin, consisting of the casts of stems, and impressions of the foliage of

coal plants. These are generally of the family of filices, or ferns, arundinacea, and aquatic plants. Of the former, many well preserved specimens are found in the shale at the "Grotto of Plants," two miles below Marietta, and also at Barris's cave, below the mouth of Big Hockhocking. I have not noticed any fossil shells or animal remains.

26.—*Slaty and compact Micacious Sand-stone.*

Above the lower calcareous shales, lies a deposit of slaty sand-stone, supporting a bed of slaty shale, containing nodules of argillaceous ore, on which rests a deposit of coal. This deposit is more fully developed in the township of Roxbury, range No. 11, township 8, and section 6, than at any other place where I have seen it. Near Marietta, these slaty sandstones lie near the base of the hills. They vary in thickness, at different places, but may be estimated at twenty feet.

27.—*Coal.*

Resting on the slaty shale, we find a bed of coal. It is of a poor quality, containing veins or layers of slate, with considerable sulphuret of iron. It varies in thickness, from a few inches to two feet,—and is one of the last, if not the very last deposits of coal in this part of the valley. About 100 feet higher in the series, in a coarse sand-rock, we find a deposit of dark carbonaceous matter, which probably was the result of vegetable decomposition, similar to fossil charcoal. The coal extends over a considerable space, and can be traced from the southerly branches of Wolf creek, across the Muskingum river, to Duck creek. It may be estimated at 18 inches.

28.—*Sand-rock.*

This deposit extends for a long distance near the base of the hills bordering the shores of the Muskingum and Ohio rivers. On the latter stream, it is often seen in mural precipices rising to the height of 59 or 60 feet; especially above the mouth of the Hockhocking, and at various other points between that place and the mouth of the Muskingum. It stretches westerly and northerly across the county of Washington, into Morgan, and southerly into Athens and Meigs, rising into lofty hills about the mouth of Shade river. The structure and external character of the rock is somewhat various at different places, changing from a loose gravelly conglomerate to a compact sand-stone. Some portions of this deposit appear to be made up of the broken fragments of the secondary and carboniferous rocks—and we find imbedded fragments of bituminous coal, round masses of argillaceous sand-stone, slate clay, &c. scattered here and there amongst the sand and gravel, which enter into the composition of this rock. A section of the strata, from the river bank to the tops of the hills, was taken at the outlet of the Hockhocking, 16 geographical miles south of Marietta, but 25 by the course of the river, and at one or two intermediate places. At Barris's grotto, a beautiful cavern, just below the mouth of this river, we find this rock resting on a bed of argillaceous shale, and composed of loosely aggregated puddingstone, or very coarse sand, containing very small pebbles and coarse gravel, cemented by tufaceous lime, which, as the rock crumbles away by the action of the atmosphere, frosts, &c., falls out in thin layers. Mixed

with the gravel, are small fragments of madrepore, and bits of carbonized wood. This portion of the deposit makes about 18 feet. The upper portion is a compact, rather coarse sand-stone, composed chiefly of silicious sand and clay. It lies in heavy masses, and where there are natural crevices passing vertically through the deposit, it often falls out in large blocks, and is seen lying at the base of the cliffs. These are split into rectangular blocks, for building stone, and furnish a valuable and indestructible material for this purpose, bearing the vicissitudes of the climate without change of texture. The upper portion of this bed, in some places, contains a stratum of coarse, sharp sand, cemented by silicious matter, which would make good filtering stones. The compact portions of the deposit are extensively quarried for cellar walls, range work, bridges, &c. at Marietta—60 feet.

Grottoes and Caverns.

The lower portion of this rock, where it is composed of coarse materials, abounds in grottoes, some of which are large and very beautiful. The most extensive and perfect of these are near the mouth of the Hockhocking, but are common from there to the outlet of the Muskingum, and seem to be formed by the joint action of air and water. There is, generally, a small stream pouring over the face of the grotto, and often falling from the height of 30 to 40 feet. The roofs and sides are sometimes beautifully ornamented with natural fret-work, resembling the cells in a honey comb, and are usually 4 or 5 inches deep and 3 or 4 broad. They seem to be formed from the wasting away of the sandy portions of the rock, while the argillaceous retain their places. This is effected by a beautiful natural chemical action; small crystals of the nitrate of lime form on the surface of the rock, and throw down the sand, grain by grain, until a cell is formed. The face of the cliff is often ornamented in the same tasteful manner. The "Laurel Grotto" is situated on Mr. Gill's run, a mile from the mouth, and is 20 feet in depth, 100 feet in length, and in front 30 feet in height, forming a semi-circle, and resembles a half section of the interior of a regular architectural dome; over the roof of this dome the water pours, after showers, with great force, on to a floor of slaty argillaceous sandstone. A little higher up the stream, immense cliffs line the sides of a deep chasm, at the head of which is another grotto and a water-fall of 40 feet. The cliffs here are clothed with hemlocks, (*abies canadensis,*) and the kalmia latifolia; a wilder and more romantic spot can hardly be imagined, rivaling, in beauty and grandeur, the cliffs of Queer creek.

29.—*Argillaceous Sand Rock.*

Resting on the cavernous sand-rock, we find a bluish-colored hard rock, with a finer grain. It contains but little mica, and affords a good material for architectural purposes, but does not work in the quarry so easily as the upper part of the rock below it. The superior strata in this bed are of a slaty structure, or are deposited in layers of a few inches, some of which make a good flagging-stone. This rock can be traced along the hill sides for many miles, both on the Ohio and Muskingum, and is worked at several places for materials in constructing the locks and dams now erecting in the latter river. The thickness varies from 20 to 30 feet. The value of both these rocks, for architectural purposes, is much enhanced, from the fact of their containing *no fossil vegetable remains*, which are common to all the sand rocks below these, in the

coal series West of the Muskingum. They seem to have been deposited posterior to the epoch of the coal formation. This deposit may be esti mated at 20 feet.

30.—*Fine-grained stratified Sandstone.*

Color, light bluish gray; contains but little mica in the body of the stone, but considerable in the seams which divide this deposit into layers of great uniformity of surface. They vary in thickness from a foot or more to two inches. The bed and surface faces are very smooth, and require but little dressing to fit them for rounding into grindstones, to which use this deposit is found to be finely adapted. Many hundred grindstones are annually manufactured from this rock in the township of Warren, a few miles below the mouth of the Muskingum, and sent to the towns West and South on the Ohio. This portion of the series may be estimated at 25 feet.

31.—*Yellow, Ochery Shale,*

Containing nodules of the red oxide of iron scattered through the bed. This ore is seen on the hill sides, at various places, but is not sufficiently abundant to be valuable—4 feet.

32.—*Micaceous, slaty Sand-rock,*

In layers of a few inches thick—contains a large portion of white mica, splitting, on exposure to the weather, into thin laminae, and crumbling into a light colored clayey soil, which often crowns the tops of the lower hills, near the rivers. The deposits above this, on many of the ridges bordering the outlet of the Muskingum, have been wasted away, either by the action of the water in seeking its present level, or from the denudating effect of rain and frosts. Some of the higher ridges still retain them. It may be estimated at 40 feet.

33.—*Red Shale*

Near the tops of the hills, a little back from the rivers, we find almost everywhere a deposit of red shale, containing flat and kidney shaped masses of red oxide of iron. It is a rich, heavy ore; the specific gravity of some specimens being 4, 16. It approaches a haematite, and affords a tolerable material for burnishing. This deposit is found in all the hills from below the mouth of Shade river, to above Marietta. In the townships of Olive and Lebanon, in Meigs county, bordering the Ohio, it is said to be deposited in beds of several feet in thickness. I have seen the ore, but have not visited the locality. The deposite of red shale may be estimated at 8 feet.

34—*Slaty Sand-rock*

At "Barris's Grotto," just below the mouth of the Hockhocking, the hills rise to 80 or 100 feet higher than those near the mouth of the Muskingum. The upper strata are composed of slaty, argillaceous sandstones, varying from a foot to a fourth of an inch. These deposits crumbled down and, mixed with vegetable matter, compose the soil on the tops of the higher ridges.—Thickness, 80 feet.

REMARKS.

The rock just described, appears to be the most recent, in that long series of deposits, which were made west of the Muskingum, above the calcareo-silicious rock. As to the diluvial, or alluvial beds, which were probably formed on the coal measures, near the time of the receding of the ocean from this part of the valley, they have been long since wasted away by the degrading forces which cut down the beds of the rivers to the depth of three or four hundred feet, and furrowed the whole face of the country into those uneven surfaces now displayed in the ridges between the streams. No earth is seen on the hills, but such as may be formed from the disintegration of the rock strata on which it is based.

SALT SPRINGS.

Early history of the Salt Manufacture in Ohio.

Muriate of Soda, or common Salt, is so intimately connected with the economy and comforts of civilized man, that a short sketch of its early history, (although in a manner foreign to a geological report,) and of its manufacture in Ohio, can hardly fail to be interesting, and worthy of our notice. As a branch of the geology of the State, there is no portion of it more vitally connected with the welfare of the people, than those deposits which furnish the materials for our salt wells.

From the period of our first organization as a member of the Union, the "*Salt Springs*" arrested the attention, and received the fostering care of our legislatures. Even before we had become a State, and were yet "a territory," the great value of the Salines had attracted the notice of our most sage and prudent citizens; and, in the compact made with Congress, distinct and express stipulations were entered into for setting apart the most noted salt springs, and a considerable territory around them, for the benefit of the State; they being considered as too valuable to fall into the hands of individuals, who might create a monopoly. At the present period, when culinary salt is so cheap an article, it may seem strange to us, that our fathers should have been so careful to preserve salines, the waters of which were so weak as to require six hundred gallons to make fifty pounds of salt. But when we remember, that at the period referred to, before this territory became a State, the price of salt varied from four to six dollars a bushel, and that the larger portion of it was brought across the Allegheny ranges of mountains, on the backs of pack-horses, we need not wonder at the high value placed upon these saline waters. At that time, they were the only ones known in Ohio, and it was not even suspected or imagined, that at the depth of a few hundred feet, many portions of the valley were based on a rock, whose interstices were filled with exhaustless quantities of brine, of such strength that one twelfth part of the quantity would make a bushel of salt. This article, so valuable, and so scarce in those early days as to be looked upon almost as a luxury, has since been so abundant as to sell for half a cent a pound.

The all-wise and beneficent Creator, who formed this earth for the habitation of man, has stored it with all things necessary for his comfort and happiness. Geology has disclosed the interesting fact, that in every region remote from the Ocean, He has deposited in the rocky strata of the earth, vast magazines of salt. The interior of Africa, Asia, Europe and America, contain, either in the form of rock or native salt, brine springs,

lakes, or effloresences, an ample supply for the wants of all the inhabitants.

Portions of the valley of the Ohio, if not the whole of it, from its north eastern extremity to its western outlet, may be said to be based on saliferous, or muriatiferous rocks, affording an abundance of water highly charged with the muriate of soda. There are many evidences of its stretching along the western and northern base of the Allegheny range of mountains, amidst the coal and sand-stones of that region, and extending as far north and west as these interesting formations are found. If the salt-rock extends as far north as Lake Erie, of which there are some indications, it probably lies at a considerable depth. Near the Ohio river, the strata which lie over the muriatiferous rocks, consisting of alternate beds of sand-stones, lime-stones, coal, quartz-rock, slate clay, marls, shales, &c. in various modifications, amount in thickness to more than twelve hundred feet. This great accumulation of deposits is made up of distinct beds, which increase in number and in thickness as we proceed south, but grow thinner and crop out on the surface, one after the other as we travel north and west from the Ohio river. From this arrangement, the muriatiferous rocks are reached at a less depth near the margin of the basin, than they are towards the center. The remark is confirmed on the western and northern sides of the coal measures in Ohio, by facts connected with the boring of salt wells.

Remarks on the Salt producing Rocks.

The rock which furnishes the most salt water, and perhaps the only rock which contains muriates, is a white, porous sand-rock. It, however, in some places, has a reddish appearance; the color being ascertained from the fine powdery sediment brought up by the tube, used for this purpose, and by the workmen called "*a pump.*" On the Muskingum, near M'Connelsville, there are two distinct strata of this rock, known as the upper and lower salt-rocks. The distance between them is over four hundred feet. The upper one is about twenty-five feet in thickness, and affords much less brine than the lower bed. The lower rock is forty feet in thickness, and not only furnishes a stronger water, but also an unlimited quantity. It is of a loose, porous structure, and often contains cells of several inches in diameter, through which the auger passes in boring without any resistance, indicating that portions of the rock had wasted away, and left it of a heavy honey-comb structure. A similar condition of the lower salt-rock has been noticed at the works on the Kenawha, Hockhocking, Leading creek, and several other places. At what depth, or in what particular rock the marine or fossil salt is *actually* placed, which furnishes the brine springs, as yet remains in doubt.

The rock in which the main saline waters are found, as stated above, is a white sand-rock of little density, and easily pierced by the drill of the well-borer. Whether particles of marine salt are imbedded and scattered through this rock, and gradually dissolve, as the fresh water from the beds above percolates slowly through it, or whether from its porous quality it imbibes and holds the brine from some rock lower in the series, is at prseent unknown. No fragments or particles of rock-salt have ever been brought up amongst the ditritus or "sludge" of the borings, as I have been informed by the workmen. The specimens of this rock in my possession, appear to be composed of a fine, light colored, silicious and micaceous sand. Whether these borings show the natural texture of the rock, or

the coarser particles have been pulverized and comminuted to this powdery condition, is also uncertain; but without doubt, their character is changed very considerably from this cause.

In the series of rock below the buhr-stone, the one most nearly agreeing in composition with this, is a loose porous sand-rock, in the conglomerate beds. Its depth, position and texture agree more nearly with the lower saline rock than any other one. While the rocks above it are either compact shales or hard sand-stones, incapable of retaining or imbibing fluids in any great quantity, this rock is in its texture similar to a bed of sand, and would receive and afford a ready passage to the water, through it in any direction. The seams and vertical cracks in the more compact beds would always afford avenues for the transmission of the brine from the lower to the higher strata. In this way it found a passage to the surface in all the old salines, presently to be described.

Calcareo-silicious, or Quartz-Rock.

This rock, although not in any way connected with the saliferous deposits, is yet an unfailing guide to the workmen on the Muskingum river, in their laborious operations of boring for salt water. Its position in the series of rocks, superimposed on the lower muriatiferous rocks, at M'Connelsville, and for several miles below that place, varies but little from six hundred and fifty feet above it. As we approcch the western and south western margin of the basin, the intermediate strata are thinner, or less in number, and the salt producing rock is reached at a less depth. Five miles above M'Connelsville, the quartz-rock is seen in the bed of the Muskingum; beyond that point, it gradually rises to the surface, so as to crop out and lie on the tops of the hills, near Somerset, in Perry county, and also a few miles north west of Zanesville. In all the wells above this spot, the workmen are not troubled with this hard rock, as they commence their work in deposits which lie beneath it. So very dense and hard is this rock, that it occupies from three to four weeks of constant labor, night and day, with an apparatus that weighs from six to eight hundred pounds, to pierce it, where only eight or nine feet thick.

The dip in the strata, although it adds greatly to the labor and expense of boring a salt well, yet fully compensates the manufacturer in the increased strength of the brine; it being found that the lower and deeper wells on the Muskingum, furnish a water more fully saturated with muriate of soda than the wells higher up the stream. The same remark will apply to all salt wells located near the margin of the coal measures. This may be partly owing to the effect of specific gravity in the saline particles, and partly to the gradual descent of the water along the inclined plane of the rock strata, thereby dissolving a larger quantity of muriates, in a manner somewhat similar to the passage of water through ashes in a leech tub. The lowest well on the Muskingum, is near the mouth of Bald Eagle creek, on the south side of Morgan county, and has penetrated the rock strata to nearly 1,000 feet. Several attempts have been made at boring for salt water a number of miles below this point, but have failed from the crumbling and disintegrating quality of the red shales through which they passed in the upper strata. Below the mouth of Wolf creek, this deposit appears to have increased to two or three hundred feet in thickness, and would probably require a depth of 1,200 feet to reach the lower saline rock.

"The Scioto Saline."

This ancient and noted saline lies near the center of Jackson county, on an eastern branch of Salt creek, a tributary stream of the Scioto river. Many of the old furnaces and wells may be said to have been seated within the boundaries of the present town of Jackson. It is amongst the earliest known salt springs in the western country, and may be ranked with the "Big Bone, and Blue Licks," in Kentucky, for antiquity, from the fact of the fossil bones of the Mastodon and Elephant being found at the depth of thirty feet, imbedded in mud and clay. The remains of several of these extinct animals were discovered in digging wells for salt water, along the margin of the creek, consisting of tusks, grinders, ribs and vertebrae; showing this creek to have been a noted resort for these huge mammalia at very remote periods. When the white hunters and traders first came into the country, it was visited by thousands of buffalo or bisons, deer, bear, and nearly all the wild animals of the forest, who found the saline waters agreeable to their tastes, or perhaps needful to their health. So numerous, and so constant were the animal visitors of these springs, that at certain seasons of the year, the country adjacent was the most valuable and profitable hunting ground which the savages possessed. They were also in the practice of making salt here from very remote times, as has been ascertained from several of their white captives, who had visited them in company with the Indians. The first attempt at its manufacture by the whites, was after the close of the Indian war, in the year 1797. At that time, and for several years after, the stumps of small trees cut by the squaws, and the charcoal and ashes of their fires, where the salt water had been boiled, were plainly to be seen. The Indian women, upon whom all the servile employments fell, collected the salt water by cutting holes in the soft sand-stone in the bed of the creek, in the summer and autumn when the stream was low. These were generally not more than a foot or two deep, and the same in width. Into these rude cavities the salt water slowly collected, and was dipped out with a large shell into their kettles, and boiled down into salt. The hunters and first salt makers, pursued the same course, only they sunk their excavations to the depth of six or eight feet, and finally to twenty feet into the sand-rock, and excluded the fresh water by means of a "gum," or section of a hollow tree, sunk into the cavity. After a few years, they commenced digging wells a little higher up the stream, in the alluvion, or bottom lands, near the creek, and to their surprise, found they could dig to the depth of thirty feet, before they came to the sand-rock, which, a few rods below, filled the whole bed of the stream.

Extent of the manufacture.

The greatest quantity of salt made at the Scioto licks, was from the year 1806 to 1808, when there were twenty furnaces in operation, making, on an average, from fifty to seventy bushels per week. During this period, it was worth $2.50 per bushel, or five cents a pound. These furnaces were located along the borders of the creek for the distance of four miles. At one time, there were fourteen furnaces in operation near the town of Jackson. At that early day, the roads were generally mere "bridle paths" through the woods, and nearly the whole amount of salt made was transported in bags, on pack-horses, and distributed through the middle and western portions of the State.

Early legislation on the Salines.

That we may understand the high value placed on the Salines, both by Congress and the people of Ohio, it will be proper to revert to the legislative acts on this subject, and to know that the grant was made with express stipulations that the State should *never sell them*, nor lease them for a longer period than *ten years* at any one time. In the year 1803, amongst the earliest proceedings of our legislators, we find an act regulating the leasing and the managing of the "Public Salt Works." An agent was appointed to take charge of the lands, to lease small lots for digging wells and erecting furnaces, and to see that no individual or company monopolized the manufacture of salt. To prevent which, it was expressly enacted that no one person, or company, should work more than 120 kettles, nor less than 30. For this privilege, the lessee paid a rent to the State of twelve cents per gallon on the amount of capacity of his kettles, annually. A fine of $5 per kettle was laid on every person who made salt without a license. The agent himself was forbidden to engage in any way in the manufacture of the article. In the year 1804, the rent was reduced to four cents per gallon, and the amount limited to 4000 gallons of capacity. In 1805, the rent was again reduced to two cents, and in 1810 to 5 mills. At this time, a much stronger water had been obtained on the Kenawha, by boring into the rock strata to the depth of one hundred feet. In February, 1812, the Legislature appropriated $300 to defray the expense of boring two hundred feet; and in 1813, they appropriated $1500 for the same purpose, which does not appear to have been expended. In 1815, the State ordered 750 dollars, to pay the expense of boring to the depth of 350 feet, under the direction of Wm. Givens, with a proviso that the water procured must be of such strength as to make 50 pounds of salt from 250 gallons of brine. It seems that Mr. Givens executed the work faithfully, and then added another 100 feet to the depth on his own expense, as I am informed by Mr. Crookham, who was amongst the earliest of the salt makers, and from whom much of the history of the first proceedings in digging wells, &c. was obtained. At this depth, viz. 450 feet, the boring ceased. A stronger water was procured, but it was in small quantity, and did not rise to the top of the well; probably from a deficiency of carburetted hydrogen gas, which, at several other works, rises in great volume, and forces the water for many feet above the surface. "Forcing pumps" for raising the water were not then in use, as they now are, at the various salines. No less than 15 acts were passed on the subject of the Scioto Salt Works, while under the control of the State.

The "Delaware Salines."

This ancient saline was located in Delaware county, Brown township, quite without the margin of the coal measures. At this reservation it does not appear that much salt was ever made, as only four or five acts were passed in relation to it. In 1809, Moses Bixby applied for leave to make certain improvements, and to manufacture salt at that place, which was granted. In 1817, a lease of the Delaware lands was given to Jos. Eaton, on condition of his making improvements thereon, amongst which was a a salt well, or boring of 200 feet in depth, which he completed, and procured salt water of such strength, that 200 gallons made 50 pounds of salt. The quantity, however, was very limited; and, in 1818, he bored one

hundred and one feet deeper, but, at 288 feet, struck a rock so hard, that he only penetrated thirteen feet in three months, with the labor of three and four men daily. After this time, it seems that no further attempts were made at the salt manufacture. These springs appear to rise in a similar formation to those of the Greenbrier valley, in Virginia, viz., a carboniferous limestone. There, several weak muriate of soda springs are found by boring; but these deposits are more celebrated for their sulphur springs, than for those of salt water.

The "Muskingum Salines."

These salines were located on Salt creek, in the present Salt creek township, Muskingum county. An agent was appointed for the Muskingum Salines as early as 1804, but no law regulating them was passed until the year 1809. The brine here, from a boring of 300 feet, was of such strength as to require 250 or 300 gallons of water to make 50 pounds of salt. Two or three furnaces were in operation for several years. Stronger water being found on the Muskingum river, they were abandoned about the year 1820. At this location, the famous "*silver mine*" experiment took place in the same year, and the sum of 10,000 dollars uselessly expended by the "Muskingum Mining Company;" all which expense and chagrin, with our present knowledge of geology, might have been avoided.

In the year 1826, after obtaining the consent of Congress, all the "salt reservations" were finally sold. They had, for several years, been a bill of expense to the State, and afforded no profit to the lessees, as salt could be made much cheaper at the stronger salines on the Big Kenawha and Muskingum rivers.

Gallipolis Salines.

This saline is seated on Chickamoga creek, a little below Gallipolis, and was the next in point of time, where salt was made in Ohio. It was commenced by Mr. Fletcher and General E. Tupper, in the year 1807. The brine varied but little in strength from that of the Scioto saline, from which it is distant about 30 miles in a S. E. direction, and required about 600 gallons to make 50 pounds of salt. In 1809, these enterprising men penetrated the rock strata, by boring to the depth of 100 feet, and procured a stronger water, 400 gallons of which yielded a bushel of salt. This was the earliest attempt ever made in Ohio, at boring the rocks in search of water. The first that was made West of the mountains, was in the year 1807, on the Big Kenawha, by Col. D. Ruffner. After this time, wells were sunk at this saline to the depth of 500 feet, but the brine procured never required less than 200 gallons to the bushel. Several wells were sunk, and furnaces erected, by different persons, and salt made there, until within about a year. At this period, the manufacture has ceased, unless revived since August last—the superior strength of the water on the Kenawha and Muskingum, enabling the manufacturers there to sell salt for a less price.

Leading Creek Saline.

This saline lies about 35 miles northeasterly from the Scioto saline, and about 18 miles North of Gallipolis, and further within the coal measures. It is seated on Leading creek, in Rutland township, Meigs county. The

first salt well was opened here in the year 1822, by B. Stout, Esq., at a point about 8 miles above the mouth of the creek. It had been, from the earliest knowledge of the hunters and first settlers, a noted lick for wild animals in the summer months. Hamilton Kerr, a celebrated ranger, had made salt here in the year 1796, by boiling the water in his camp kettle, collected by diging holes in the sand, at a time when the creek was nearly dry. Four other wells have been bored since Mr. Stout's; three below him and one above. The average depth of the wells is 450 feet. The calcareo-silicious rock dips below the beds of the streams in Wilkes township, about 12 miles West of the Salines, and is said to be reached at the depth of 180 feet below the surface, or bed of the creek, which would only carry the wells to the upper saline rock. At Mr. Stout's well, a bed of coal was passed at less than 100 feet, which is said to be six feet in thickness. Directly after piercing the coal, the auger opened a fountain of spring oil, or petroleum, which discharged a number of barrels in a day, and continued to come up copiously for several days. The discharge of carburetted hydrogen gas from this well was immense at first, throwing the water to a height of more than 33 feet, as they were putting a tube into the well, for the exclusion of fresh water. The flow at this time, after the lapse of 15 years, is still very copious, and made with great regularity at intervals of about forty minutes; and continuing to throw up the water violently in the well head, or cistern, for about ten minutes at each paroxysm. This singular phenomenon takes place with great regularity, and has been measured accurately with a time-piece. The gas is eliminated by a natural chemical process, continually going on in the bowels of the earth, and is considered by "well borers" an omen of salt water, as it almost invariably is found near salines, either discharging, through some natural crevice in the rocks, where it is called "*a burning spring*," or rising with the brine in the salt wells. The water at this saline is a stronger brine than that farther West, and nearer the margin of the coal basin. It requires rather more than 100 gallons for 50 pounds of salt. The "Pomeroy coal bed" is here found at an elevation of about 150 feet above the creek, and six feet in thickness; affording a valuable article of fuel in boiling the water. At a well four miles below Mr. Stout's, the boring was continued to 800 feet, without any additional strength to the brine, or increase in quantity.

The Hockhocking Valley Salines.

As we proceed, easterly, from the margin of the coal measures, the next salines are found in the valley of the Hockhocking. The earliest indications, it is said, were observed in the crystallization or efflorescence of salt on the sand and stones in the bed of the river, at low stages of the water during the summer months. A well was first bored by J. Pugsley, about the year 1820, in the township of Dover, Athens county, on a small run, three or four miles from the mouth of Sunday creek. Since which, two other wells have been sunk, one a little above the mouth of the creek, on the bank of the Hockhocking, and one six miles north on a small branch that falls into Sunday creek. The water in the wells located on the small branches, is less copious than at the one near the shore of the river; confirming the remark which has before been made, *that large streams of water are necessary in the immediate vicinity of salt wells, to insure a full and free supply of brine.* At the well, one mile above the mouth of Sunday creek, on the bank of the Hockhocking, the water is discharged with great force and freedom, rising in "the well

head" twenty feet above the surface of the river at common stages of the water, and running in a constant stream at the rate of 12,000 gallons in 24 hours; a free discharge of carburetted hydrogen no doubt accelerates the rise of the water from the cavities in the rocks below. It is estimated that this well affords sufficient brine for 110,000 bushels of salt in a year; with their present single furnace, about 40,000 bushels are now made. The water at these salines is considerably stronger than at those West of of here, containing over ten per cent. of muriate of soda, and making a very pure salt, but little deteriorated with muriate of lime or "bitterns." This per cent. will require nearly 75 gallons of brine to 50 pounds of salt, which is about equal to the Kenawha water. The average depth of the wells in this vicinity is rather over 530 feet; from which it would seem that the boring was commenced some distance below the calcareo-silicious rock, as no similar rock is passed, on inquiring of persons who were engaged in the work. We find a like dip in the rock strata here, to that on the Muskingum, as we proceed southeast down the river, so that at Stroud's run, seven miles East, and four miles South, making about nine miles in a S. E. direction, it requires a depth of 800 feet to reach the salt rock. A boring was recently made for salt water nearly opposite to the village of Nelsonville, ten miles above the mouth of Sunday creek, to the depth of 630 feet, but without success. Twelve miles above this point, the conglomerate which underlies the coal measures, is seen lying in the bed of the river, seeming to indicate that the muriatiferous rocks are unproductive near the margin of the coal basin. Some of the finest beds of coal in the State are found in the vicinity of these salines, and are in use as a fuel at the salt furnaces. The Hocking Valley Canal passes directly through these rich deposits of coal and salt, and must ultimately make them of immense value to the proprietors, and to all the interior of the State, where these products can be transported on the canals, which, like the vessels of the human frame, will, in a few years, meander through all parts of the body of the republic, carrying health and strength to every member.

Salines of the Muskingum Valley.

The most valuable portion of these muriatiferous waters are located in Morgan county, along the margin of the river, and about 25 miles northeast from the last described salines. Here we approach nearer to the centre of the coal basin in Ohio, and find a corresponding increase in the strength of the salt water. It has not yet been satisfactorily ascertained how far up the Muskingum river and its branches the saline deposits extend; but certainly as high as Coshocton, and probably as far north as the south line of Stark county, as salt water is abundant on Yellow creek, east of this point, and from thence downward to the mouth of Bald Eagle creek, on the south side of Morgan county. All along this line, a distance of 60 geographical miles, the saline rocks are found gradually sinking deeper and deeper into the centre of the valley from a depth of 250 feet to that of 1,000. At Zanesville salt water is obtained at 350 feet. At Taylorsville, nine miles below, at 450 feet. At M'Connelsville, eighteen miles further southeast, at 750; and at Bald Eagle it is nearly at 1,000 feet. The strength of the brine increases in about the same ratio, so that 50 gallons from the lower wells afford as much salt, as 250 from the upper ones. By an analysis of the water, from R. P. Stones well, near M'Connelsville, made by Proffessor Mitchell, it yielded as follows—viz: from four ounces there was obtained,

Of Muriate of Soda,	269 grains.
Muriate of Magnesia,	20 grains.
Muriate of Lime,	15 grains.

It also contained some carbonate of iron, and showed a point trace of iodine. From this analysis the water affords nearly 14 per cent. of salt, besides the other muriates. The water from the lower well at Bald Eagle is supposed to be still more fully saturated. The first well sunk on the Muskingum river, was near the mouth of Salt creek in the year 1817, since which period up to the present time, there has been bored sixty-one wells, to which are, or have been attached nearly as many furnaces; but a large number of them are now out of use. Of this series, forty-two wells below Taylorsville, eleven between that place and Zanesville, and eight above Zanesville; three of which are in Coshocton county. As to the annual quantity of salt, at present manufactured in the valley of the Muskingum, I am not fully advised, but suppose it to be about about half a million of bushels; and may be increased to meet the wants of the country. The improvements in the navigation of the river now in progress, will greatly facilitate the transport of this valuable commodity to market, during the summer months, as well as in the spring and autumn.

Petroleum and Carburetted Hydrogen.

These two interesting productions of the beds of bituminous coal which lie deep in the earth, are found to accompany the salt water in nearly all the wells. In some they are very abundant; in others, the quantity is so small as to be barely perceptible. Where gas is discharged freely, it greatly assists the ascent of the water in the well, and saves the expense of forcing it up by the aid of a pump worked either by a horse or steam power. If constant and abundant, as it is at R. P. Stone's well on the Muskingum, it might also be conducted by pipes under the kettles, and used as a fuel in boiling away the brine, thus relieving one of the heaviest items of expenditure in working a furnace. In some wells the discharge of gas is periodical, and at intervals of eight or ten days, bringing up with it large quantities of petroleum, to the amount of several barrels. This is the fact with a well in Olive township, on the east side of Morgan county, and west branch of Duck creek, twenty miles east of M'Connelsville; at this well the discharges of gas are tremendous, throwing the water all out of the well to the height of thirty or forty feet. These eruptions are attended by a flow of petroleum, which, for the first few years, amounted to from thirty to sixty gallons at each paroxysm, and returning at intervals of two to four days. They are now less frequent; and the discharge of petroleum is about a barrel per week. The well was bored in the year 1814. For the collection of such vast quantities of gas, there must be corresponding cavities, in which it may be treasured up until they become so full as to overcome the resistance of the superincumbent water, and force a passage to the surface. Collections of the same nature sometimes take place in the earth at a distance from the rivers or salt wells. At a locality near the gravel coal beds on the Hockhocking, the earth and rocks have been blown out to a considerable distanee, leaving a cavity of several feet in diameter and depth. Probably the true reason why saline fountains are commonly attended by inflamable gas, is, that the coal formation, and salt deposits are, geologically, close neighbors, the salt being usually above in Europe and other countries, but not so in the valley of the Ohio, or in the valleys of its confluent

streams. It appears from the facts noted in these remarks, that the main salt rock lies below the coal. This compound gas is the same as that which collects in such quantities in the coal mines of England, and by its explosion proves so destructive to the lives of the miners.

I have not yet visited the salines on Big and Little Yellow creeks, and am not prepared to give a description of the improvements there.

S. P. HILDRETH,
First Assistant Geologist, and Palæontologist.

REPORT

OF

DR. KIRTLAND,

SECOND ASSISTANT GEOLOGIST.

No. 3.

CINCINNATI, *December* 3, 1839.

To Professor W. W. MATHER, *Chief Geologist:*

SIR: In pursuance with the letter instructions, which I had the honor to receive from you, bearing date "Columbus, June 23d, 1837," I proceeded forthwith, "to collect and arrange, in a scientific manner, the various objects of the recent animal and vegetable kingdoms in this State."

I am happy to inform you, that I have progressed so successfully with most of the branches belonging to the departments assigned me, that my catalogues already afford evidence, that Ohio is rich in species, so far as Zoology and Botany are concerned.

As the People generally appear to feel a deep interest in the success of the undertaking, and we are indebted to the public spirit of their Representatives, for its commencement, and support; and it is due to them, that they should be informed of every circumstance, in regard to both its progress, and anticipated results.

With this view, you will permit me to notice some of the advantages that are expected to arise from investigating the several branches committed to my charge. It is designed to make out as full and perfect catalogues as possible of all our Animals, from the minutest insect and reptile, to the largest mammalia, and of all our vegetables; arranging them according to their classes, families, orders, genera and species; giving each both its scientific and common name, and at the same time noting any peculiar or important character it may possess.

Also, to collect and prepare specimens of the various species, as far as practicable, for the use of the State. If suitable means be taken, afterwards, to preserve them, they will compose a standard Cabinet, to which all classes of citizens can resort, either for amusement, or for the more profitable pursuit of acquiring a knowledge of the Natural History of this section of the country. And although it cannot

be expected that one individual will be able to make out a perfect collection, during the time that will probably be allowed for completing the Geological Survey; yet it may be made so extensive as to form the basis or nucleus, to which additions will be constantly made, by the labors of naturalists, who will be stimulated to exertion by the collection already formed.

The study of the several systems of Natural History is peculiarly calculated to discipline the mind, and it is desirable to introduce it as a branch of education among the rising generation. This can be done in no manner so effectually, as by laying the foundation contemplated in making such a collection. It will afford facilities for pursuing the study in every portion of the State.

The names and terms employed in these branches may appear dry and uninteresting to any except the votaries of science, yet we daily see the want of a knowledge of them, in the confusion that arises from popular names and descriptions of natural productions. "A striking instance of this may be found in the celebrated Kotzebue's narrative of his banishment to Siberia, in the course of which he discovered a plant, which attracted his admiration, and which he has described *at great length*, as one of the most beautiful flowers he had ever met with. A very moderate acquaintance with botanical science would, however, have informed him, that this plant, if one may venture to form a judgment from his account of it, was already known to most parts of Europe by the name of *Cipripedium;* and the only doubt which remains is, as to the particular species of the plant, a doubt which his description, does not, after all, enable us to clear up."*

A correct application of half a dozen terms would have decided the point with so much certainty, that if that plant were afterwards found in any other part of the world, even the most remote, it would be recognized by Botanists.

Perhaps some may still inquire, Of what practical utility are these investigations? We would reply, that man derives his nourishment and support from the productions of the animal and vegetable kingdoms; but, while some contribute to his comforts and enjoyments, others again tend to interrupt or destroy them.

The Naturalist, by becoming familiar with the habits and characters of these productions, is enabled, on the one hand, to select and appropriate to use those that are valuable; and, on the other, to reject such as are detrimental, or to correct their evil tendencies.

There are, doubtless, many species belonging to both these kingdoms that possess useful properties, that are now neglected, and are rapidly disappearing before the progress of cultivation and improvement. Most of the larger mammalia have already become extinct in Ohio. Forty years since, the Bison (*Bos Americanus*) visited our borders; at this time, few or no Elk (*Cervus Canadensis*) remain, and the common Deer (*Cervus Virginianus*) are comparatively rare. Notwithstanding they all have once existed in great abundance on our

* Roscoe's Address to the Proprietors of the Botanic Garden at Liverpool.

frontiers, it yet remains to be decided by experiment, whether they might not be domesticated, so as to become serviceable as beasts of burthen or as articles of food.

All of our domestic animals were originally as wild, and perhaps as unpromising in their habits as either of these; yet, by a long course of training, and by familiarity with man, have entirely changed their dispositions. We have no evidence, so far as I am informed, to show that the Bison might not be successfully taught to yield its neck to the yoke as well as the Ox. It is said, that in some parts of the East Indies, the Buffalo (*Bos bubalus,*) which is analagous to our Bison, is employed for carrying burthens and for draughts.

The Elk and Deer will, without doubt, be domesticated, as objects of curiosity, if not of profit, as our State advances in improvements and luxury.

There is another family of animals that deserves more attention; I allude to the *fur bearing*, including the Beaver, (*Castor Fiber,*) Otter, (*Lutra Brasiliensis,*) and Musk-rat, (*Fiber Zibeticus.*) The sources from whence the supplies of fur are derived, are principally the northern parts of Russia and northern and western parts of America. The energy with which the Fur Trade has been carried on, for the last thirty years, has rapidly exhausted these sources, particularly the latter; and it is said by those experienced in the business, that they will fall far short of satisfying the increasing demand before the end of twenty years. It therefore becomes an object worthy of enquiry whether some or all of those kinds of animals might not be profitably domesticated for their peltries.

From my own experience, I know that both the Beaver and the Otter will, with a little attention, become as docile and as obedient to the commands of man as most of our *household* animals; and I am convinced that, in localities where abundant supplies of suitable food are found, as great profits might be realized by breeding them as are anticipated from the productions of the Silk-worm in this country.

We are indebted to our native feathered tribes for two important species of barn-yard poultry—viz: The wild turkey, (*Meleagris Gallopavo,*) and the mallard, or green headed wild duck, (*Anas domestica.*) This number might, no doubt, be greatly and advantageously enlarged by other additions from the *Lamellosodentati* and the *Gallinaceæ.*

The same means that have domesticated the aforementioned species would transfer from their native haunts to our yards and fields, the Canada goose, (*Anas Canadensis;*) brant, (*Anas bernicla,*) widgeon, (*Anas Americana*), dusky-duck, (*Anas obscura*), wood-duck, (*Anas sponsa*), teals, (*Anas discors et crecca*), canvass-back, (*Fuligula valisnera*), pochards, (*Fuligula ferina*), and other eatable ducks; the prairie hen, (*Tetrao cupido*), pheasant, (*Tetrao umbellus*), and the quail or partridge, (*Perdix Virginiana*).

The early settlers of this State derived abundant supplies of fish from the different rivers; but of late, many of the finest species have forsaken their resorts, owing in a great measure to the obstructions

occasioned by the construction of so many dams. It is also worthy of enquiry, whether some provision should not be made by law to protect them, so far at least as to make it necessary to provide a sluice-way in every dam sufficient to allow them a free passage up and down the streams, in conformity to their instinctive laws of migration. And also, whether it might not be made a profitable business to construct artificial ponds in favorable situations, for the purpose of breeding the finest kinds of *fish*. In other countries it is often done by turning small streams of water, or by enlarging and improving springs. It may be done here in many situations with trifling expense.

Our reptiles are few, and generally insignificant. I know of none that can be employed for any convenient or profitable use. The venomous species are rare and will soon become extinct within our borders.

Humble and insignificant as are the insect tribes, they materially influence the condition of man. Among those which may be said to be enlisted in his service, the honey-bee, (*Apis mellifica*), is one of the most conspicuous: another is the silk-worm, (*bombyx mori*).

It is not improbable that some of our native *coccoon-spinning* insects may be found to answer as valuable purposes as the silk-worm.

Experiments have already decided that some of the American cantharididæ are at least equal to the foreign species for medicinal purposes.

The list of those insects that may be considered as interrupting the enjoyments of man, or interfering with his comforts, is much more extensive. It embraces, among many others, the wheat-fly, (*cecidomyia destructor;*) the bee-moth, (*galleria cereana;*) curculio, or plum-bug, (*cryptorhynchus cerasi;*) rose-bug, (*macrodactyla subspinosa;*) peach-tree borer, (*ægeria exitiosa;*) apple-tree borer, (*saperda bivittata;*) and the cut-worm, (*noctua præmordens.*) The naturalist, by becoming familiar with their economy, is often enabled to devise means to counteract their injurious tendencies. Mr. Say discovered that a small parasitic insect, the *ceraphron destructor*, infests and destroys large numbers of the Hessian fly, and is, probably, the natural means that restrain the ravages of that enemy to our wheat crops. From my own experience, I know that swine will exterminate, in a great measure, the curculio-bug from a plum orchard, in the course of two or three years.

By knowing the habits of insects, we can often obviate their attacks. The farmer may find it advantageous, in those sections of the State where the Hessian fly is common, to either postpone sowing his seed until the time for depositing the egg of the insect has passed, or to substitute spring for winter wheat; and it is also probable that some of the winter varieties of this grain may yet be found with stalks so solid that they will resist the attacks of this enemy. Many years since, the timber in the navy yards of Sweden was rendered unfit for use by the perforations of a small worm. The Government applied to Linnæus for a preventive of its attacks. He recommended to have the timber sunk in water during the few days that were occupied by the insect in depositing its eggs. The remedy was perfectly effectual,

and, simple as it was, saved more than a million of dollars annually to his country.

The vegetable kingdom opens a wide and fertile field for the inquirer, in the applications of its productions to the purposes of the artist, husbandman and physician.

We know, at present, very little about the number and value of the coloring materials that may be derived from this source; but it is certain that, in many instances, our native dyes, when set with suitable mordants, form as permanent and durable colors as any obtained from the more expensive foreign materials. Many of our indigenous vegetables contain fibrous substances in their wood, bark, roots or leaves, which may, on trial, be found important substitutes for hemp and flax in the manufacturing of cordage, cloth and paper. Of this class are some of the neules, (*urticaria*,) Indian hemp, (*apocynum*,) and milk-weed, (*asclepias*.) Aquatic plants and algæ may yield the best materials for paper; and the silky down attached to the seeds of the common milk-weed, and contained in the follicles of that plant, may, perhaps, furnish an important substitute for cotton, feathers, down and fur.

Among our native grasses are some species that would equal or surpass any now in use, if they were selected and cultivated by themselves.

The fine varieties of fruits with which our orchards and gardens abound, are the remote offsprings of the most inferior and unpalatable kinds; the apple sprung from an austere crab, and the peach from a dry, woolly fruit, nearly destitute of pulp. Their improved conditions have resulted from cultivation. It is worthy of inquiry whether the *custard, apple, papaw*, (*asimina triloba*,) might not be made to break into rich and palatable varieties by artificial means.

Of the numerous native plants already known to possess active medicinal properties, few have been subject to close investigation; and there are very many which contain equally active and probably valuable properties that have been entirely overlooked. The success that has attended the few limited attempts at bringing into use our indigenous medicinal plants, show that it is an important subject; and it is evident that our materia medica might be enriched by the additions of many rare vegetable articles from our forests and fields.

The limits of a report will not allow me to pursue the subject further. This view of it, though concise, is perhaps sufficiently minute to show that an investigation of the animal and vegetable kingdoms may be of great practical utility to the public at large, as well as to science. The arts, agriculture, and science, are so mutually dependant on each other, that one cannot be greatly advanced without a reciprocal advancement of the others.

I would briefly add, that I have already collected and prepared, for the use of the State, numerous specimens in several of the branches assigned to me, which I will forward to Columbus as soon as a safe and suitable receptacle is provided for them.

I am, sir, very respectfully yours,

JARED P. KIRTLAND,

Second Assistant Geologist of Ohio.

REPORT

OF

C. BRIGGS, JR.

FOURTH ASSISTANT GEOLOGIST.

No. 4.

To Professor W. W. Mather,

Principal Geologist of Ohio.

Sir: In the letter of instructions which I received from you as Chief Geologist of the State of Ohio, dated June 23d, 1837, I am directed to "take charge of the geological investigations which will be made between the waters of the Scioto and Hockhocking rivers"; embracing the counties of Scioto, Lawrence, Gallia, Athens, Hocking, and Jackson; and to report to you the progress of my labors, on the 1st of January, 1838. In obedience to these instructions, I have now the honor to Report:

That I repaired, as soon as practicable, to the district assigned me; and having made a reconnoissance of it, proceeded to the detailed examinations.

As, for obvious reasons, the surveys of particular counties, or districts, cannot be completed until the whole ranges of strata, of which they embrace only a part, shall have been explored, most of the economical facts, collected during the detailed examinations, will be communicated while describing the strata embraced in the reconnoissance. This reconnoissance was made, in order to facilitate the subsequent investigations, by first determining the great geological outlines of the district.

With a view to ascertain the relative position of the strata, their dip, direction, general characters, and economical value, it was found necessary to make several sections in the line of dip, not only across the counties which have been mentioned, but to extend them into Pike, Ross, Adams, and Highland. These objects have been so far accomplished as to determine, with some degree of precision, the general geological features of the State, and the vast extent of her mineral resources.

In accordance with your instructions, it has been constantly borne in mind, in all our investigations, that *practical utility* is the primary object which induced the Legislature to authorize the survey; and, leaving out of view the great benefits which are conferred upon the community by investigations in purely scientific Geology, our examinations have been sufficiently extensive to show, from economical considerations alone, that this enterprize, if conducted to its termination, with that spirit of enlightened liberality heretofore characteristic of Ohio in her appropriations for public works, will not only give a new and immediate impulse to the general interests of the State, and to the individual prosperity of her citizens, by fully disclosing, at an early period, the treasures now concealed in the bowels of the earth, but confer invaluable benefits upon those who will come upon the stage when the present generation shall have passed away.

RECONNOISSANCE.

The strata of that part of the State embraced in the reconnoissance, the boundaries of which have been heretofore described, are composed of nearly horizontal and alternating layers of limestones, sandstones, shales, coal, and iron ores, to the depth of more than two thousand feet. They have been worn down and denuded, in every direction, apparently, by vast bodies of moving water, so as to form irregular hills, valleys, and ravines, giving to the surface the very rugged and uneven appearance which we now observe. There can be no doubt that the strata were originally deposited beneath the surface of an ocean, in nearly horizontal layers;—but as this is not the proper place for theoretical discussions, it need only be observed, on this subject, that this erosive action may have been produced by the elevation of the strata from beneath the surface of the ocean, causing tremendous currents of water to sweep over the yielding rocks in various directions, forming valleys and ravines, and scooping out basins for small lakes, or ponds, which have been subsequently filled with stratified deposits of clay, sand, or gravel. This modification of the surface by water, has not only afforded great facilities for geological investigations, but made easy of access exhaustless treasures which otherwise would have remained concealed in the bowels of the earth.

Dip of the Strata.

Before proceeding to a description of the rocks, embraced in the reconnoissance, some definite notion should be formed of their dip and bearing, and the obstacles which may be encountered in their examination. This is very important, in a practical point of view.

The rocky strata of the district assigned me for examination, consist, as before observed, principally, of limestones, sandstones, shales, coal, and iron ores, superimposed upon each other with parallel planes of stratification. They dip, or are inclined, towards the east, or east southeast; but so slightly, that their inclination is scarcely perceptible

to the eye, excepting where long levels can be taken, on the water courses. This remark can only be applicable to the amount of dip over large areas; for the strata are always more or less undulating, and in a manner calculated to deceive the inexperienced, by local variations, not only in amount, but in direction. For example, the general dip is, perhaps, not more than 30 feet in a mile; while undulations, in some instances, cause it to be more than double that distance. A gentleman, to whom I am under obligations for much local information, ascertained the local dip, by actual measurement, to be, in one situation, 28 feet in a quarter, or 112 feet in a mile. This undulating character of the strata, which are nearly horizontal, often causes a local dip, not only in the line of bearing, but sometimes in a direction opposite to the true one. From what has been observed, it will be readily seen, that to ascertain the absolute amount and direction over extensive areas, will be a work of difficulty. It is one, however, of much practical importance to the community, as it is a necessary preliminary in successfully tracing the valuable mineral deposits of the State, and directing explorations for treasures, concealed from observation beneath thick masses of materials of little economical value. As this object cannot be effected in situations where the dip can be observed only for short distances, it will be necessary to ascertain its amount in two directions, over considerable areas, or as far as any stratum can be traced before it disappears beneath the water courses; and then, from data thus obtained, to make the calculation trigonometrically. As the rocks are conformable, it is not necessary that the same stratum be used in both directions. This labor will be greatly facilitated by the surveys which have been made by the State, for canals along the valleys and principal rivers. This method of ascertaining the dip over extensive areas, is only an extended application of a principle suggested to me by yourself.

Difficulties in Geological Examinations.

It may be proper here to remark that, although the geology of this portion of the State is exceedingly simple, no inconsiderable difficulties will attend its examination. It is true that the water-courses, in many places, present fine sections of the rocky strata; but they are so worn down by the action of water, and their surfaces so covered by debris, that it is often difficult to trace their continuation from point to point. They undulate irregularly, while their inclination is very slight; and they are so variable, even in short distances, that little reliance can be placed on either external characters or mineral composition. A coarse conglomerate in one place, is a fine grained sandstone in another; a bed which is composed of argillaceous materials, at one locality, at a short distance, may be entirely silicious; and a stratum, embracing coal, iron or other valuable materials in a particular locality, may, in another, be entirely destitute of them. Were it necessary, other examples might be adduced. These have been cited, as they have an important bearing in practical geology; having been impressed upon our minds, by the frequent, and in some instan-

ees, ludicrous mistakes which have occurred, by attempting to refer rocks to their proper geological position, by external characters alone —the only sure criteria being organic remains, and actual order of superposition.

For convenience of description, the strata have been separated into seven groups or subdivisions, which, it is believed, correspond with important eras, or changes, during their deposition. They will be described in the order of their superposition, beginning with the lowest and ascending in the series. Figure 4, of the plate, will illustrate their relative position, as observed in traveling eastward, from Adams and Highland counties, to the Ohio river.

I. The first subdivision, (marked B,) includes the limestone of Adams and Highland counties, and is, probably, merely a continuation of that which forms the rocky strata of the whole western portion of the State. This limestone is of great thickness, and contains, where it has been examined, the petrified exuviæ of radiated and molluscous animals of marine origin, some of which belong to extinct genera, and all to extinct species. These reliquiæ of a former condition of our planet, are so abundant, that the conviction is forcibly impressed upon the traveler's mind, that he is treading upon the floor of an ancient ocean.

Many ages must have elapsed and a peculiar condition of our planet prevailed, during the deposit of this vast mass of carbonate of lime, as it is composed of numerous layers extending to the depth of more than 600 feet,* and contains throughout its whole extent myriads of petrified relics of animals, many of which must have lived and died where we now find them entombed.

II. In this division (vide C, fig. 4, of the plate) there appears to have been an important change, not only in the materials which were deposited, but in their organic contents. Reposing upon the limestone already described, occurs a body of argillaceous slate, two hundred to three hundred feet in thickness, in which animal remains are rare. This slate is thinly laminated, and, according to the rules of geological interpretation, must have been deposited, at successive intervals, in quiet waters.

III. The rocks superimposed upon the argillaceous slate (vide D, fig. 4, of the plate) appear to have been deposited under conditions no less remarkable than the two preceding divisions. Instead of the uniformly tranquil state of the two preceding periods, the strata bear evidence of having been formed in waters alternately quiet and disturbed. Under these circumstances, were deposited the whole series of this division, which consists of alternate layers of fine-grained sandstone and shale, attaining a thickness of not less than three hundred feet. The layers of sandstone appear to have been formed in a gradually shoaling bay, estuary, or sea, for they are characterized by ripple marks, which, it has been stated by Mr. Conrad, can only be made in shallow waters. These markings are sometimes so surpris-

*It has been penetrated 6 00 feet in search of salt water

ingly regular and beautiful as to appear artificial, rather than natural, slightly resembling the flutings on some ornamental columns. But in proof of this, reference need only be made to the aquatic vegetables which are found on the surfaces of some of the layers; and which were apparently entombed in the place of their growth.

IV. Resting on the alternations of sandstones and shales, occurs a stratum, (vide E, fig. 4, of the plate) which was formed under conditions widely different from those which prevailed during the deposition of the strata which have been mentioned. It consists of coarse silicious sandstone and conglomerate, both of which frequently pass into each other, according to the variable velocities of the water in which the materials were deposited. That part of the stratum which is conglomerate, is composed principally of quartzose sand and pebbles, the latter of which are variable in size, from a pea to two or three inches in diameter. These materials are partially united, sometimes with iron, and at others, it would appear, merely by adhesion; the pebbles are rounded by attrition, and strongly resemble shingle on the sea-shore. These pebbly materials were, doubtless, deposited by currents of water of unequal velocities, but sufficiently strong to move them onwards, and distribute them over an area of vast extent, leaving the sand in one place, the gravel in another, and the coarse pebbles in another, and so on,—thus producing the various changes which we now observe, and causing the stratum, even in short distances, to pass from sandstone to fine conglomerate, and from the latter to one very coarse in its texture.

This deposite was probably made in the vicinity of dry land, as, near its junction with the strata of the third division, are found the remains of a few terrestrial vegetables.

V. Superincumbent upon the conglomerate, is a series of deposites (marked F, in fig. 4, of the plate) which indicates another important era or change. In the *preceding* period, were strong currents of water, depositing only coarse sand and pebbles; in *this*, the waters were less disturbed, and often tranquil, and so varied, and charged with materials, as to produce layers of sandstone, limestone, shale, coal and iron ore; thus forming a series of strata some hundred feet in thickness, containing rich supplies of the most useful substances for the necessities and comforts of man. During this period must have flourished extensive forests of terrestrial plants, as we find their remains scattered with great profusion through the whole of this series of strata.

VI. The next division (vide G, fig. 4, of the plate) is a rock only a few feet in thickness, but so remarkable in its character, so continuous, and requiring conditions for its formation so widely different from those of any other rocks in the State, that it deserves especial attention. This rock has been called buhr, from its strong resemblance to the buhr-stone of the Paris Basin, and its use in the construction of mill-stones, to which both have been applied. This rock is chiefly composed of silex, but it occasionally contains some calcareous matter. Unlike others of which we have spoken, it seems to have been a deposition from waters containing the materials in chemical solution. It is characterized by the remains of molluscous animals.

VII. This division (indicated by H, fig. 4, of the plate) includes the series of strata above the buhr. It consits of alternations of sandstone, limestone, shale, coal, and iron ore, and may be considered the upper member of the coal formation.

With these preliminary remarks, we proceed to the description of the several divisions, or groups of strata, which we have thus slightly noticed.*

I.

GREAT LIMESTONE DEPOSITE.

Commencing, then, in Adams and Highland counties, the first rock with which we meet is a vast body of fossiliferous limestone, which not only forms the basis of those counties, but stretches west and north to the boundaries of the State, forming the subjacent stratum to a soil of great fertility. The thickness, range, and economical value of this extensive stratum cannot be ascertained until the whole western portion of the State shall have been thorougly explored.

This division presents two varieties: The lower member is gray, bluish gray, and sometimes nearly black; it is sub-crystalline, and, as before observed, abounds with the fossil remains of extinct marine animals. Among them have been observed trilobites, orthoceratites, ammonites, terebratulæ, productí, encrini, &c. &c. This part of the formation occupies, according to Professor Riddell, but a small part of the area of the State, being principally confined to the southwestern counties.† It has been called by that gentleman "the blue limestone district."

The area of the State, embraced by the upper or more recent member of this limestone has been named "the yellow limestone district" by Professor Riddell, who remarks, in the report to which reference has been made, that "this geological district is perhaps four times greater, in superficial measurement within the State, than the one just described; extending, as it does, from Adams, Highland, Green, and Montgomery counties, northward to Michigan and Lake Erie, and from the shale regions on the Huron and Oleontangy westward, doubtless, beyond the State boundary."

Both these kinds of limestone are of great value for agricultural and architectural purposes, for which they have been quarried and used in various parts of the State. Some of the finer varieties have been polished and used for ornamental work, as jambs, mantel-pieces, &c.‡

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*Arrangements have been made, since writing these preliminary remarks, so that Dr. Hildreth will describe the sixth and seventh divisions indicated on the profile by the letters G and H.

†Professor Riddell's report to the last Legislature.

‡ NOTE. I have referred neither the limestone above described, nor the superincumbent rocks, to any particular class among the fossiliferous strata, though there can be scarcely a doubt as to their geological position and their European equivalents, as may be inferred from their organic remains and lithological characters. On this subject may be quoted the judicious remarks of Prof. W. B. Rodgers, of the Virginia geological survey. He says: "We hold it to be altogether premature, while the geologists of America are yet only on the threshold

II.

Argillaceous slaty rock, or shale stratum.

Progressing eastwardly from the limestone to the western borders of Scioto, Pike, and Ross counties, the limestone sinks beneath the water courses, and is succeeded by a stratum of argillaceous slate, the entire thickness of which is, perhaps, two hundred to three hundred feet. It forms the base of the hills which are capped with sandstone along the western border of the Scioto valley, from Chillicothe to Piketon, and probably nearly to Portsmouth, although the rocks dip slightly in that direction. The color of this stratum is variable, but is generally grayish, or approaching to black; in some places, it contains so much bituminous and carbonaceous matter, that it can be ignited; and, hence, many have inferred that coal may be found within its geographical limits; but, so far as my observations extend, there is little prospect of finding it in sufficient quantities to be valuable. Coal has, however, been observed, according to Mr. I. D. Lapham, in thin seams, an inch or two in width.* This stratum can be examined to advantage on Paint Creek, a few miles east of Bainbridge, and, indeed, through the whole of the valley on that stream to Chillicothe.

As this stratum was more particularly examined by J. W. Foster, Esq., acting assistant on the survey, I may be allowed to quote from an abstract report, some of his valuable observations: "On the silicious limestone is superimposed a thick bed of shale. You have a good view of it at Copperas Mountain, a few miles east of Bainbridge. Its base is washed by Paint Creek, a stream of some thirty yards wide, running into the Scioto. This mountain attains, by estimation, a height of three hundred feet. The shale is exposed two hundred and fifty feet, with sandstone above, say fifty feet. The talus has been washed away by the stream as fast as it fell, so that there is a perpendicular face of nearly 150 feet exposed. The beholder hardly walks beneath these jagged and beetling cliffs with feelings of security. They have yielded, slowly and reluctantly, to the combined assaults of the storm from above and the stream below. In many instances, the torrent, descending from above, has cut out deep gorges in the shale, so that, at a distance, it resembles the ruins of some vast and antiquated castle.

After having gained by a circuitous route, the top of the cliffs, the pedestrian has to clamber up an escarpment of disintegrated shale be-

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of their researches, to endeavor to establish an identity of *names* between our strata and those of Europe. This too frequent error prejudices all the broader and more lofty generalizations of the science. In a spirit of caution, therefore, dictated by the many blunders daily committed in the nomenclature of our rocks, we shall abstain from giving them a class of European names not always, indeed, applicable in the countries where they are employed, and certainly less so in a region of widely different structure, separated by the great interval of the Atlantic. The little that can be said, in a detailed way, upon particular strata, will be descriptive, being convinced that points of nomenclature and classification cannot be ventured upon with profit until there shall have been collected a vast deal more minute information than is now before us."

*Riddell's report to the last Legislature.

fore he attains the summit. The prospect is sufficiently beautiful to repay him for his toil. The cliffs, which from below presented so threatening an aspect, dwindle into insignificance. Here, the ravages of the elements are still more perceptible. They have scooped out large hollows in the cliffs, which are gradually becoming deeper and deeper. From this spot the eye ranges for miles, over a valley of unparalleled fertility, chequered with forests and farms; while far below, the creek sweeps on in its serpentine course, bordered on one side by frowning precipices, and the other by tangled thickets. Few places in Ohio afford a lovelier or more extended prospect.

This shale is very fissile, contains considerable bitumen, and when rubbed exhales a fetid odor. Towards the bottom of this stratum are imbedded masses of fetid carbonate of lime, varying from one to two feet in diameter. These often present a spheroidal appearance outwardly; while within, they exhibit concentric layers, formed around nuclei. These nuclei are amorphous masses, often traversed by *calc spar and sulphate of baryta*. They seem to constitute an interesting variety of *septaria*. No attempt will here be made to explain their spheroidal structure.

The following are some of the principal minerals which occur here: *Fetid carbonate of lime*, *calc spar*, *sulphate of baryta*, *sulphate of alumine* and *potash* (alum) in the form of efflorescence, resembling mould, and investing the shale; also in tuberose masses. It falls down and can be gathered up in considerable quantities. *Sulphuret of iron*, (pyrites) in nodulur masses. *Sulphate of iron*, (copperas) in a yellow efflorescence with the alum."

The three last named minerals are, probably, all which may prove to be of much economical value.

The copperas and alum are produced by the decomposition of the sulphurets of iron by atmospheric agents. The sulphur uniting with the oxygen of the atmosphere, forms sulphuric acid, which, according to circumstances, either combines with the iron to form copperas, or with alumine and potash, to produce alum. These salts, in some places, are produced in so great abundance, that their efflorescence causes considerable areas to appear as if covered with a heavy frost.

Nodular masses of sulphuret of iron are, in some places, so numerous, that they may be used, together with the shales in which they occur and are decomposed, in the manufacture of copperas, which has already been made from these materials for domestic use. It is by no means impossible that beds of gypsum may be found near the junction of this rock with the subjacent limestone, as no other circumstances are necessary for its production, than the decomposition of large quantities of sulphuret of iron in connection with strata of carbonate of lime, so that the sulphuric acid formed from the sulphuret, coming in contact with the latter, produces sulphate of lime, or gypsum.

This enormous mass of argillaceous materials gives rise to numerous chalybeate springs, which are not only valuable for their medicinal properties, but their waters, charged with ferruginous matter, under favorable circumstances, deposit it in the form of bog ore, in sufficient quantities to be used in the manufacture of iron.

This stratum, which at first sight would appear to be of little importance, may prove to be of great value.

III.

WAVERLEY SANDSTONE SERIES.

Superimposed upon the stratum above described, occurs a series of alternations of sandstone and shale, the thickness of which has not yet been ascertained, but which will not probably vary far from 250 to 300 feet.

The lower part of this stratum caps the highest elevations near Chillicothe, and it can be studied with great advantage on either side of the Scioto valley, from Chillicothe to Portsmouth. Traveling eastward from this valley, it gradually sinks lower in the hills, till it finally disappears beneath the water courses. It continues some miles above Portsmouth, on the Ohio river; and on the road from Chillicothe to Jackson, disappears beneath the streams about four or five miles from the latter place, so as to form the lowest rock which emerges to the surface in Jackson county, and the one upon which reposes all the strata within its boundaries.

Although the sandstone embraced in the series of strata, the geographical boundaries of which have just been described, may, for the most part, be distinguished by its external appearance; yet, great variations have been observed in its character at different localities, caused by the variable proportions of its component parts, or the occasional absence of one or more of them.

This sandstone is chiefly composed of fine silicious sand; but, in many places, contains variable proportions of argillaceous matter, oxide of iron, and carbonate of lime. Its color is also variable. It is generally white, bluish gray, or tinged with shades of yellow. It is formed of layers, from one inch to five or six feet in thickness, on which are seen ripple marks, produced by the motion of water before the rocks were consolidated. Entombed in these layers are also found the remains of a few marine vegetables, and some zoophytic and molluscous animals: the latter are the most numerous near the junction of this series with the conglomerate which lies above it. In the inferior part of this series, Mr. Foster obtained a few casts of multivalve shells, replaced by sulphuret of zinc.

This series of strata will ultimately be of immense value to the State, as it affords durable and beautiful building materials. It is now wrought, to some extent, for architectural purposes. Some of the finer varieties are of great value for ornamental work; and being nearly as beautiful as some kinds of primitive marbles, may be mistaken for them, at a distance. At those localities where argillaceous matter cements the silicious grains which form the sandstones, they should not be used in situations exposed to the vicissitudes of the weather, as, under such circumstances, they readily exfoliate and fall to pieces, by the combined action of rains and frosts. Some of the

thinner layers afford abundance of beautiful stones, admirably adapted to flagging. Near the junction of this rock with the one which lies above it, whetstones of a very good quality have been obtained.

The fine grained sandstones of this series have been quarried at Portsmouth, Piketon, Waverley, Chillicothe, and other places; and are favorably known in most of the principal towns in the State. Quarries without number may be opened, so that all demands, however great, may be supplied. The limits within which these quarries may be opened, will be determined by subsequent detailed surveys.

As some of the most beautiful stones that have been obtained were quarried at Waverly, we may, for the present, denominate these rocks the *Waverley sandstone series.*

IV.

Conglomerate.

Resting on the series last described, occurs a stratum which is composed of silicious sand and pebbles; it varies in thickness, where it has been observed, from 40 to 80 feet. This, like the preceding, (and it is true of all strata of sedimentary origin,) cannot be identified, at different localities, by external characters alone. In some places it is a fine silicious sandstone, which cannot be distinguished from the stratum which lies above it; in others, it is a conglomerate, chiefly composed of quartzose sand and pebbles, the latter varying in size from a pea to two or three inches in diameter. Sometimes it is strongly cemented by the oxide of iron, and at others the sand and pebbles are but partially united, so that it rapidly crumbles away by the action of frosts and rains. It is of the greatest importance that this rock be carefully studied, and its position, range and extent accurately described, as it forms one of the landmarks, or monuments, by which some of the most interesting and valuable deposites in the State may be traced.

This rock is continuous from the Ohio river, in the eastern part of Scioto county, northward, through the western part of Jackson and Hocking, to Fairfield county. According to Mr. Ewing, of Lancaster, it swells out on the Hockhocking river to a much greater thickness than I have any where observed it.

V.

Lower coal series.

A few miles east of the conglomerate, and above it, in order of superposition, occurs a series of strata composed of sandstone, limestone, shale, coal, and iron ore, the aggregate thickness of which is between 300 and 400 feet. This series occupies a belt of country several miles in width. It commences on the Ohio river, and embraces the eastern part of Scioto county, and the western part of Law-

rence; thence it extends northerly, so as to include a large proportion of Jackson county, the extreme west of Gallia, the west part of Athens, and the east of Hocking county. In this series are three layers of workable coal, three or four layers of limestone, several of iron ore, from one inch to five or six feet in thickness, with numerous strata of sandstone and shale, all of which can be applied to useful purposes. It embraces a group of associated minerals, which, when they shall have been fully explored, will be exhaustless sources of wealth, not only to those in whose immediate vicinity they occur, but to the whole State.

Sandstones.

The lowest and most important stratum of sandstone lies a few feet below the first workable bed of coal, and about 30 feet above the conglomerate. This rock varies from 40 to 70 feet in thickness; it is chiefly composed of silicious sand, but in some places contains quartzose pebbles, and, hence, may be mistaken for the conglomerate. It is sometimes colored and cemented by oxide of iron, and at others, it is nearly white, containing but little ferruginous matter. In some places coal, externally resembling charcoal, is disseminated through the rock. This stratum affords a material suitable for building, and has been quarried for the construction of furnaces. The village of Jackson, Jackson county, is built upon this rock, which can be examined to advantage in that vicinity.

Above this rock occur only two other sandstones which now require description. The first, from 35 to 40 feet in thickness, is situated a little more than 100 feet above the one last described, from which, in many places, it cannot be distinguished by external characters. This rock, like the preceding, will afford materials for building and the construction of furnaces. It has been quarried in the vicinity of McArthurstown, and used for flag-stones, underpinning, and tombstones. For the latter purpose it has been recently introduced.

The principal stratum of sandstone above this is inferior to it in thickness, but approaches so nearly to it in charater, that a separate description of it, at this time, will be unnecessary.

Shales.

The argillaceous shales of this series are of some importance in an economical point of view. Their prevailing colors are yellowish, gray and black. They contain, in some places, so much carbonaceous or bituminous matter as to burn freely when ignited. They generally form the floor and roof of the coal strata, and in such situations often contain beautiful impressions of extinct vegetable remains. In these shales are found embedded most of the iron ores. As they are impermeable to water, while the sandstones suffer it to pass through them, they are generally the water-bearing strata, and hence, wherever they are found, give rise to numerous springs, which are most abundant on the eastern slopes of hills, as the strata dip in an easterly direction.

As in Europe, so in this country, the disintegration of the shales which form the floor of coal deposites, produces fire-clays. Some in this series may be valuable for the manufacture of those articles for which such clays are required. This can only be determined by experiment or chemical analysis.

Clays, or shales, occupying the situation above mentioned, have been obtained at Coal Grove, eight miles above Hanging Rock, on the Ohio river, and used in the manufacture of stoneware. Subsequent examinations may show that this useful material can be obtained in great abundance.

Limestones.

The limestones of this series are interesting, not only as affording a flux for the iron ores of this region, and lime for the various uses to which it is usually applied, but are also of great value for agricultural purposes.

Three layers of limestone have been observed. The first is a gray or grayish white micaceous limestone, variable in thickness and composition at different places. It contains more or less silicious sand, and, in some localities, is very difficult to distinguish from a gray micaceous sandstone. Indeed, I am inclined to believe that this stratum passes into sandstone in which not a trace of lime can be detected. Its geological position is a few feet above the first workable bed of coal. It has been traced from the northern part of Scioto county, through Jackson, to Athens county. It may be seen four miles south of Jackson, on the road to Burlington; it is again exposed in the bed of a small stream, about two miles north of Jackson, on the road to Athens. At Reid's mill, ten miles from the former place, is a sandy limestone, 10 or 12 feet thick, which may belong to this stratum, although the question of its identity is not entirely settled. Here much of it is light colored and sandy, and, unless closely examined, would be passed by as sandstone. It makes good lime for mortar, but, of course, will not bear so much sand as lime made from rocks which contain less silicious matter.

A limestone, identical in appearance and composition with that at the first mentioned places, occurs in Elk township, a mile or two northwest of McArthurstown.

The second stratum of limestone lies about 100 feet above the preceding stratum, and is from 18 inches to 8 feet thick where it has been observed. It is uniformly of a dark color, nearly black, and contains the remains of radiated and molluscous animals of marine origin. The layers vary in thickness from four inches to one foot, and, alternating with them are seams of dark colored shale. This limestone breaks out into oblong blocks, of suitable size for building purposes. This stone will probably bear a polish, and if so, can be used for ornamental purposes, as jambs, chimney-pieces, &c. The organic remains will add greatly to its beauty when polished.*

*Since writing the above, a piece of this dark fossiliferous limestone has been polished. It is nearly or quite equal in beauty to the best Egyptian marbles. If it can be obtained in sufficient quantities, and in blocks sufficiently large, as I think it may, it will be of immense value for ornamental architecture.

This rock has not been as yet discovered south of Jackson courthouse, though it probably exists. It may, however, thin out in that direction. But north of Jackson village it has been observed in several places in the county. Loose masses of it are very abundant in some parts of Lick township, where it has been burnt for lime; it exists there also, *in situ*, but no quarries have been opened. In Milton township it also occurs; there it was observed, *in situ*, in the vicinity of Little Raccoon Creek. It is well exposed in Athens, about two miles south of McArthurstown, where it forms the bed of a small stream; here it breaks out in oblong masses, and the fissures are so arranged that the bed of the stream appears as if paved with flags.

The third layer of limestone in this series is from 4 to 12 feet in thickness, and lies one hundred feet or more above the one last described. It is a gray, sub-crystalline, fossiliferous limestone. From this stratum is taken the limestone used in fluxing the iron ores. It is very valuable for this purpose, and also for the manufacture of lime.

There remains to be mentioned another stratum of limestone, the relative position of which has not been determined. It occurs in the south, or southwest part of Jackson county, on the land of John Canter. The whole stratum may be 10 or 12 feet thick. The superior part is white, or nearly so, and is fissured in almost every direction. The lower part is sub-crystalline, and, in some places, beautifully shaded with green and red; and if it can be polished, and obtained in sufficient quantities, will be very valuable in ornamental architecture.* Some beautiful specimens were obtained from a slab which had been quarried to use in the manufacture of millstones. This stratum should be examined with more attention than we have been able to devote to it the present season. It affords a material for the manufacture of lime of an excellent quality, and may also be used as a flux in reducing the iron ores of this vicinity.

Coal.

As it is not our present purpose to attempt a full explanation of the formation of coal, a few remarks only need be made on the subject.

Its vegetable origin is almost universally admitted. By the ablest geologists, it has been considered as resulting from the distribution of large masses of vegetable matter over a previous deposition of sand, gravel, mud, or argillaceous silt, and subsequently covered with the same materials; all of which have been indurated so as to form conglomerates, sandstones, and shales; while the vegetable accumulation by pressure and chemical changes, has been converted into coal.

Evidences are not wanting, to prove that the various coal strata have been formed in this manner. In their associated shales and sand stones, once in the form of sand and mud, we find entombed numerous

* Since writing the above, some of these specimens have been polished. We cannot ascertain, with accuracy the value of this rock for ornamental architecture, from the polishing of a few hand-specimens; but it is believed that this stratum may be used for that purpose.

remains of plants, some of which, with their most beautiful and delicate foliage, are as perfectly preserved, as if they had been most carefully prepared to ornament the herbarium of the botanist. Between the laminar divisions of the coal itself, the vegetable structure can often be distinctly seen. In many situations are found numerous silicified stems, or trunks of trees, belonging to those primeval forests from which our fossil fuel has probably been accumulated. Some of these stems, or trunks of ancient trees, varying in size from a few inches to two feet in diameter, have been so flattened by the pressure of the superincumbent sandstones, shales, &c., as to make the greater diameter nearly four feet. The silicified remains of these ancient forests are, in some situations, so numerous as to be truly astonishing. One of the most remarkable localities is on Shade river, about six miles from Athens. Here they are so abundant, that many teams may be loaded with segments of fossil trees, which have been left exposed by the degradation of the adjacent sandstones, in which they were formerly entombed. It is remarkable, that although these fossil plants resemble in structure those flourishing at the present day in tropical climates; yet, none of them are now known to exist on the surface of our planet.

Dr. Buckland, in speaking of the splendid exhibitions of fossil plants in the coal mines of Bohemia, says: "The most elaborate imitations of living foliage upon the painted ceilings of Italian palaces, bear no comparison with the beauteous profusion of extinct vegetable forms with which the galleries of these instructive coal mines are overhung. The roof is covered as with a canopy of gorgeous tapestry, enriched with festoons of most graceful foliage, flung in wild, irregular profusion overy portion of its surface. The effect is heightened by the contrast of the coal black color of these vegetables with the light groundwork of the rock to which they are attached. The spectator feels himself transported, as if by enchantment, into the forests of another world; he beholds trees, of forms and characters now unknown upon the surface of the earth, presented to his senses almost in the beauty and vigor of their primeval life; their scaly stems, and bending branches, with their delicate apparatus of foliage, are all spread forth before him—little impaired by the lapse of countless ages, and bearing faithful records of extinct systems of vegetation, which began and terminated in times of which these relics are the infallible historians.

"Such are the grand natural herbaria wherein these most ancient remains of the vegetable kingdom are preserved, in a state of integrity little short of their living perfection under conditions of our planet which exist no more."*

Coal of the Hocking Valley.

The coal of this valley, and its associated minerals, iron and salt, will, at no distant day, be extensive and lucrative articles of com-

* Bridgewater Treatise, vol. 1, page 344.

merce; and when our noble system of internal improvements shall have been completed, will find their way into every county in the interior of the State, not only increasing her revenue from the canals, but adding permanently to the general interests of her citizens.

Before speaking particularly of this interesting valley, acknowledgment should be made for the valuable information received from Hon. Thomas Ewing, who, by his accurate knowledge of local geology, facilitated my investigations by spending some days with me in the examination of the most important localities.

In this series, so far as my observations now extend, are three workable seams of good bituminous coal, successively cropping out at the surface on the Hockhocking river, between the mouth of Sunday creek and a point four to seven miles west of Nelsonville. The course of the river, here, is nearly southeast. These layers of coal, separated from each other by layers of sandstone, limestone, shale, &c., gradually rise in the hills, in ascending the river, but in an opposite direction, sink in them, till they finally disappear beneath the bed of the Hockhocking; occupying a distance along the river of about ten or fifteen miles.

Both north and south of this valley, numerous openings will be made in these beds of coal whenever a sufficient demand shall be created by the opening of the Hocking Canal, now in progress of construction. According to information from Dr. Hildreth, the range of rocks in which these beds are situated, is continued northward through the counties of Perry, part of Licking, Morgan, and Muskingum; thence they extend, nearly in the same direction, to the Falls of the Cuyahoga. In a southerly direction, they embrace, as remarked in a general description of the strata of this series, portions of the counties of Athens, Hocking, Jackson, Gallia, Lawrence, and Scioto.

In descending the Hockhocking river from Logan, the first workable bed of coal was observed near a Mr. Brit's, about four miles west of Nelsonville. The coal here is of good quality. No opportunity occurred, to ascertain its entire thickness from personal examination; but I was informed, by individuals on whom the greatest reliance can be placed, that its average thickness may be safely estimated at four feet.

The stratum of coal next in geological position above the one just described, is well disclosed at Nelsonville, about seventy or eighty feet above the bed of the Hockhocking at that place.

As the most extensive openings have been made in the neighborhood of Nelsonville, this coal is generally denominated "Nelsonville coal." This name has been adopted by Dr. Hildreth, in some manuscript notes, with the examination of which he has kindly favored me.

This coal is from six and a half to nine feet thick, separated by a thin layer of shale from a stratum of sandstone, which will, in most places, form a permanent roof to these mines when they shall have been opened. The coal is of excellent quality. It readily splits, parallel to the plane of its stratification, into thin laminæ, on which the traces of vegetable fibre can often be distinctly seen. On account of its

thickness, extent, superior quality, permanent roof, &c., this layer of coal is one of the most valuable in the State; at least, the most so in the Hocking Valley; and will, at no distant period, exert an important influence upon the interior counties, as well as upon the vicinity in which it is located. Upon either side of the Hockhocking river, in descending from Nelsonville, openings can be made in this stratum, for four or five miles.

Above the Nelsonville coal, and below the buhr-stone, occurs at least one other bed which is workable. Coal occupying this position has been worked, in several places, in the vicinity of the salt wells, on the Hockhocking, and used in the evaporation of brine. The question as to the geological position of these openings, must be determined by subsequent examinations.

Coal of Jackson, Scioto and Lawrence Counties.

In these counties are also three beds of workable coal, which are probably equivalent to those of the Hocking valley. It will be recollected that all these are embraced in the series of strata, between the conglomerate and buhr. The western outcrop of the lowest seam may be indicated by a line drawn from the Ohio river, near the Franklin furnance, in Scioto county, northward, to Richland, in Jackson county; but, as this outcrop is irregular, coal may be found West of this line on *high elevations*, and be deficient in *those* East of it. Like the coal, which has heretofore been described, it is made up of laminae, containing distinct traces of vegetable fibre, often so thin, that a great number can be counted within the space of a few inches. This coal burns with a brilliant yellowish flame, and being free from sulphuret of iron, is very highly esteemed for fuel, and smith's purposes. In some places it appears to pass into cannel coal. On account of its purity, it may be used in the smelting of iron. It is preferred at the furnaces, by those acquainted with its character, to either of the beds which lie above it in this series; and must, at some day, be of great value to this part of the State, not only to the furnaces, but to those places on the Scioto valley, which must, ultimately, be supplied with fossil fuel from this stratum. Numerous openings have already been made in this bed. It has been used in Jackson, Athens, and Scioto counties. Four or five miles West of Jackson, this coal has been dug, and drawn by teams to Chillicothe, where it costs, on delivery, about 16 cents per bushel. It has been taken from banks, owned by Messrs. Chandler, Milligan, McKinnis, Howe, Ward, Landrum, and others. We have no data from which to estimate the quantity of coal annually taken to market from these mines; but its amount, which is increasing, must already be many thousand bushels.

Above this bed, occur, at least, two others which are workable. In Jackson county, they have not been wrought except for smiths' purposes, and in a few instances for fuel, by those living in their immediate neighborhood. The outcropping edges of these layers of coal, are found a few miles East of that which forms the western boundaries

of the coal deposits of the State. One or both of these beds will be found in the townships of Clinton, Milton, Bloomfield, Madison, Jefferson, and Franklin, in Jackson county; thence, they extend, southerly, to the Ohio river, through the easterly portion of Scioto county, and the western part of Lawrence, where they have been used at some of the furnaces.

Besides these three beds, there are some thinner ones, which, perhaps, may be wrought in a few localities.

We have thus given a brief description of the coal of this group of strata, the aggregate thickness of which is variable, but it may be safely estimated from 10 to 12 feet, though in some places it may be 17 feet.

These three layers of coal, with the strata in which they are embraced, are so abraded, and their debris removed, that they occupy only a small portion of the area, included between their western outcrop, and the point at which they disappear beneath the beds of the streams.

The whole amount of coal between these points, from the Ohio river, north, to the Hocking valley, may be safely estimated as sufficient to form an entire stratum, 50 miles in length, 5 miles in width, and 9 feet in thickness. This amount of coal will yield about 9,000,000 of tons per square mile. This estimate includes but a very small part of the coal, which can be obtained from the beds heretofore described; for, after disappearing beneath the water courses, they, doubtless, continue, eastward, toward the Ohio river, sinking deeperand deeper beneath the surface, so that they can be reached only by shafts near the Ohio, at the depth of some hundred feet. The method of obtaining coal, by sinking shafts, has not yet been practiced in this country to any considerable extent; but will, ultimately, be in Ohio, when the consumption of fossil coal shall have created a sufficient demand for the article. Shafts have been sunk, with success, under the direction of practical geologists, in Great Britain, to the depth of 1200 to 1500 feet. Coal must, undoubtedly, be obtained in this way in our own country, at no very remote period.

Iron Ores.

In describing the geographical boundaries of this series of strata, the limits of the iron ore region were defined; the first bed of ore occurs not many feet above the conglomerate, and is succeeded by others, at greater or less intervals, to the buhr. These several layers or seams of ore, vary in thickness from an inch to 5 or 6 feet, and are, generally, associated with, and embraced in, beds of shale, with which they were contemporaneously formed. Their origin appears to have been from a semi-fluid mass, composed of ferruginous, calcareous, silicious and argillaceous matter, together with small portions of zinc, lead, and some other substances, but not so dense as to prevent freedom of motion between the particles of which it was composed. By the superior attraction of particles of the same kind for each other, the ferruginous particles arranged themselves around numerous cen-

tres, or nuclei, and thus formed nodular masses, composed of concentric layers, arranged over each other, like the coats of an onion. These nodules, in many instances, are so abundant, and have been subjected to so much pressure from the superincumbent layers, as to leave the interstices between them very small, and give to the beds, at first sight, the appearance of solid, unbroken layers of iron ore. By this pressure, these nodules, when not very numerous, are merely flattened; but when very abundant, the weight, from above, seems to have moved them laterally against each other, with so much force, as to destroy their original form, and curve, in various directions, the concentric coats of which they are formed.

Some of the iron ores appear not to have been formed in this manner; but a structure, similar to the one just described, can generally be discovered by close examination.

It is not intended, in this report, to discuss, fully, either the origin of the ores, or the varieties which have been observed, as, for very obvious reasons, such discussions should be deferred till they shall have been subjected to chemical analysis.

Iron Ores of Lawrence and Scioto Counties.

"The several deposits of iron ore in these counties, extending to six or more distinct beds, lie at an inclination of about 30 feet to the mile, dipping to the east southeast; and are seen, as we travel easterly, cropping out at successive, but irregular intervals, on the surface of the highest hills, at a few miles back from the river, and gradually sink deeper in the earth, are finally lost at the base of the hills, disappearing beneath the beds of the streams."*

The numerous layers of sandstone, limestone, coal, shale, &c., with which these ores are interstratified, have been worn down and cut through by degrading agents, so as to form hills, valleys, and ravines, and give to this region a wild and rugged aspect. But the inclination of the strata, which have been thus interrupted, is so slight, and the valleys, generally, so narrow, that they can be traced, without much difficulty, from hill to hill. This peculiarity of surface, although it renders the country less valuable for agricultural purposes, has disclosed, and made easy of access, its vast mineral resources.

These beds of ore, situated as they are, in a finely wooded country, being easy of access, and associated with all the materials necessary for their reduction, cannot fail to be immense sources of wealth.

The first furnace for the smelting of these ores, was erected by the Hon. James Rogers, in Lawrence county, in the year 1826. Subsequently, eight other furnaces have been erected in Lawrence county, and five in Scioto.

The names of these furnaces in Scioto are, Franklin, Junior, Scioto, Bloom and Clinton; in Lawrence county, Union, Pine Grove, Etna, Vesuvius, Hecla, Lawrence, Mount Vernon and Lagrange. Since the

* Dr. Hildreth's report to the Legislature, 1836-37.

erection of the first furnace, in the year 1826, their number has been steadily increasing. Lagrange was erected in 1836, and subsequently several locations for furnaces have been made, some of which, on account of the state of the money market, have not been erected.

As only two or three of these furnaces have been visited, and none of the ores analyzed, a detailed account of our iron ores, and the best methods of working them, must be omitted till the detailed economical geology of this part of the State shall have been completed. A few facts, however, of a general nature, may not be uninteresting on this subject; and in communicating them, we cheerfully acknowledge the kindness and hospitality with which we were uniformly received by those gentlemen engaged in the manufacture of iron on whom we had occasion to call. Great interest was manifested in the objects of the survey, and every facility was afforded us in the prosecution of our investigations. Our particular acknowledgments are due to Hon. James Rodgers, of Hanging Rock, Gen. Kendal, of Portsmouth, Rev. Dan Young, of Franklin Furnace, Mr. Murfine, of Scioto Furnace, and Messrs. Salters & McCollum, of Clinton Furnace.

Location and construction of Furnaces.

Great care and experience are necessary in selecting an eligible site for a furnace. The principal objects to be kept in view are, a sufficient supply of ores, fluxes and fuel, so near each other, and to the furnace, that they can be delivered with little expense; and so located as to afford facilities for transporting the iron to market without great expenditure. About 4,000 to 5,000 acres of well wooded land are considered, by proper attention to the second growth, sufficient to supply a furnace with charcoal for any period.

As most of the ores, now considered workable at the furnaces, are, in geological position, above the first workable bed of coal, the location should be east of it, in order to be the most favorably situated as regards the proximity of the materials to be used in the manufacture of iron.*

In these counties, the common high furnaces are the only ones which are used. They are nearly similar in construction, but vary a little in breadth and height, the dimensions of the hearth, height of the tuyere, and pitch, breadth, and perpendicular height of the boshes. The following, as the best dimensions for the construction of a furnace, were given to me by Mr. Salters, of Clinton Furnace:

* There is one bed of ore below this coal, which, as it is continuous over considerable areas, and in some localities of great thickness, requires particular notice. It has been traced continuously from the Ohio river northwardly, through the eastern portion of Scioto county, to the valley of the Hockhocking river, near Logan, a distance of more than sixty miles, varying in thickness, where it has been examined, from one to five feet. This ore generally contains silicious sand, and, in most localities, quartzose pebbles. It has been generally rejected at the furnaces, on account of the difficulty of reducing it; but I am inclined to believe that some of the better varieties may be used, by giving a different pitch to the boshes, and properly regulating the flux, &c. If future experiments shall show that this iron ore can be profitably smelted, the vast area of land on which it is found will be greatly increased in value.

"*Dimensions of Hearth, &c.*

Square at bottom of hearth.....22 inches
Square at the top.....24 inches
Height of hearth..... 5 feet
Heigh of tuyere above the bottom stone of hearth.....17 to 19 inches
Height of the tymp above the bottom stone of the hearth.....15 inches

The inclination or "batter" of the boshes should be 10 inches to the foot; and the distance across the top, from 9 feet to 9 feet 6 inches. The height of the furnace, from the bottom stone of the hearth to the mouth, or trundle-head, from 30 to 35 feet."

The above dimensions include only those which are most essential.

The furnaces are almost entirely constructed from the sandstones which are associated with the iron ores. The materials are quarried out in large heavy blocks, and la d up without either mortar or cement. The main building, or "stack," if properly constructed, will last many years; but the in-walls and hearth-stones, although constructed in the best manner, and with the best materials, will, in a short time, be destroyed by the effects of heat.

Of working and smelting Ores.

Instead of drifting or mining, as is done in working the coal beds associated with the ores, they are obtained by a process called "stripping," which consists in entirely removing the incumbent materials. Situations for this purpose are found near the outcropping edges of the layers. It has been estimated that earth, stones, &c., can be profitably removed at the rate of one foot to every inch of good iron ore, making 12 feet "stripping" to the foot. Seams of iron ore, not to exceed 4 to 6 inches in thickness, are frequently used. In working the beds around the sides of hills, the strippings gradually become deeper and deeper, till the spot is finally abandoned for another where less labor is necessary to obtain the ores.

In process of time, the "strippings" will become so deep, that it will be necessary to "drift" for the ores. This process, it is believed, will be attended with less expense than the present one, especially when the beds are of any considerable thickness, and are situated near the furnaces, as in such cases the item for transportation of ore, which is a heavy one in the expenditures of a furnace, would be greatly reduced. To obtain the thickest and most valuable beds, where they have disappeared beneath the water courses, shafts can be sunk through the rocks which overlie them; but such operations should be conducted only by men who have experience in mining operations. Before smelting, the ores from various beds are mixed and roasted. They are then placed upon a bench or platform of iron bars, separated from each other by a space of about one inch, and pounded with iron hammers till they fall through at the bottom. They are then thrown into the furnace, with one-tenth their weight of limestone, to be smelted. The ores yield from 33 to 37 per cent. of pig iron

The following statement, furnished me by Mr. McCollum, from the books of Clinton Furnace, will be interesting, as an exhibit of the relative quantities of stock used, and the iron made, in a blast of 204 days:

"CLINTON FURNACE,
Scioto county, Ohio, 1836.

Relative quantities of stock used, and iron made, in one blast of 204 days.

Charcoal	307,876 bushels
Stone-coal	30,277 bushels
Limestone	260 tons
Iron ore	2,546 tons
Pigs made	896 tons
Average quantity per day	4 t. 7 cwt. 3 qrs. 10 lbs.

Average stock used per day.

Charcoal	1,509 bushels
Bituminous coal	148 bushels
Iron ore	12 t. 9 cwt. 2 qrs. 12 lbs.
Limestone	1 7 1 22

Average stock to make each ton of iron.

Charcoal	343¾ bushels
Ore	2 t. 16 cwt. 3 qrs. 9 lbs.
Bituminous coal	33¾ bushels
Limestone	6 cwt. 1 qr. 25 lbs.

Ore used in the blast, 28,511,040 pounds; iron made, 10,161,280 pounds; which is equal to a yield of 35.64 per cent."

Mr. Murfine informs me that the ores at the Scioto Furnace yield about 37 per cent., and that the average quantity of iron made per day, while in blast, is about 4¾ tons.

In forming an estimate of the value and importance of the iron business in these two counties, (Scioto and Lawrence,) I may be allowed to quote from an able paper written by Dr. Hildreth in 1836:

"The furnaces make an average amount of 1,000 tons of pig iron per year, some of them making more than this quantity, and others less. During the past season pig iron has been worth forty dollars per ton at the landing, where the metal is delivered to purchasers. Producing an amount of iron worth five hundred and twenty thousand dollars per year, one-half of this quantity is made into castings and stoves, directly as the metal flows from the furnace, worth sixty dollars per ton, which will add one hundred and thirty thousand dollars more to the gross amount: making the sum of $650,000 as the product of these thirteen furnaces. The number of furnaces is steadily on the increase, several new ones going into operation the present year; in addition to which, the bar-iron manufactured at the forges will swell the present amount to a considerably larger sum. Each

furnace employs, on an average, about one hundred men, and fifty yoke of oxen, all which are fed from produce grown in these counties, and those lying higher up the country on the Ohio and Muskingum rivers, affording an extensive home market for large quantities of corn, oats, flour and bacon, and already nearly as important as that of Cincinnati to many of the river counties.

"The furnaces on the Kentucky side of the Ohio river, in the iron ore region, are quite as numerous as those in this State, and assist in giving permanence and value to this new market. When the number of furnaces is quadrupled, as they in a short time must be, from the regularly increased demand for iron in railroads, steam engines, &c., the value of the iron manufacture will be swelled to several millions, and the market for the productions of the soil be proportionally increased. So true it is, that agriculture and manufactures are twin sisters, and go hand in hand, affording mutual benefit and assistance to each other."

Iron Ores of Jackson County, &c.

It has been the prevailing opinion, that the valuable deposits of iron ore from which the furnaces in Scioto and Lawrence have been supplied, were confined to those counties; and in consequence, those in Jackson have been entirely neglected until the present season. The distance of this county from the Ohio river and the canal, has, without doubt, hitherto prevented explorations, as furnaces situated so far from water communication, could not successfully compete with those having greater facilities for transportation. A company, however, has been formed, and a site selected for a furnace, in the southwest part of this county, in Hamilton township, by gentlemen practically acquainted with the manufacture of iron. Under their direction, a furnace, called the "Jackson Furnace," is now in the progress of construction. It is thirteen miles from the Ohio river, but is considered one of the most eligible locations, on account of the proximity of the ores, limestones, &c., to the furnace, and to each other.

Much labor has been spent in tracing these iron ore deposits. They occupy the whole eastern portion of the county, being merely a continuation of those in Lawrence and Scioto. The western outcrop of the most valuable beds, may be indicated by a line drawn from Hamilton, a little east of north, to the northern boundary of the county. In some situations, where the hills are sufficiently high, good beds of ore may be found west of this line; but furnaces should be located east of it, in order to be the most favorably situated in reference to the proximity of the materials necessary in the manufacture of iron. Though none of the beds have been extensively opened, yet, from the quality of the ores, and the abundance in which they are found on the surface, by the wasting away of the rocks in which they were embraced, they are probably equal, in every respect, to those of Lawrence and Scioto counties.

This iron ore region has not been minutely explored farther north than the south line of Athens county; but subsequent examinations

will doubtless show that it extends onward to the Hocking Valley, from partial examinations in which, it is probable that ores of good quality may be obtained in sufficient quantities to justify the erection of furnaces.

In closing this hasty sketch of the iron ore and coal deposits of this series of strata, it may be proper to glance at the future importance of the manufacture of iron in this part of the State.

The prosperity of this branch of industry is always mainly dependant upon the abundance of the raw materials which must be used, and the small amount of labor and expense with which they can be obtained. Here, we have all the facilities necessary to success. The fuel, fluxes, and ores are so abundant, and contiguous to each other, and can be obtained with so little expense, that the manufacture of iron, under judicious regulations, cannot fail to be eminently successful.

At a very low calculation of the amount of good iron ore in the region which has this season been explored, it is equal to a solid, unbroken stratum, sixty miles in length, six miles in width, and three feet in thickness. A square mile of this layer—being equivalent, in round numbers, to 3,000,000 cubic yards—when smelted, will yield as many tons of pig iron. This number, multiplied by the number of square miles contained in the stratum, will give 1,080,000,000 tons; which, from these counties alone, will yield annually, for 2,700 years, 400,000 tons of iron—more than equal to the greatest amount made in England previous to the year 1829.

From this estimate, which it is believed is much too low, it appears that the iron ores of this portion of the State are not only sufficient to supply all domestic demands for ages, but to form an important article of commerce with other States.

There can be no doubt that the manufacture of iron will continue to increase for many years; and, with the exception of agriculture, it may become the most important branch of industry to the citizens of the State. To be convinced of this, reference need only be made to the constantly increasing demand for iron, the facilities for its manufacture, and the amount annually imported into this country.*

In reflecting upon the prospective importance of the iron business to Ohio, a question naturally suggests itself, as to the necessary supply of fuel; for if dependence be placed entirely upon charcoal for smelting operations, this branch of industry must be comparatively limited. And, as the forests in this ferriferous region will be sufficient to reduce only a small part of the ores, our attention, on a subject of so much importance, should not only be directed to economy in the use of fuel, and to the preservation of our forests, but to the means of obtaining a sufficient supply from some other source.

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* "The value of iron and steel manufactures imported into this country previous to the 30th of January, 1836, was $7,717,910. The year previous, the import was less than $5,000,000.

"Mr. Cambreleng's Report shows an increase in the importation of bar iron for the seven years previous to 1835, of 77½ per cent. over the former seven years, or from 1821 to 1828"—Prof. Jas. Hall, New York Geological Report, 1836—7.

Perhaps no fears need be entertained on this head, as the introduction of the hot blast, and the probability that some beds of bituminous coal will be soon brought into use for the smelting of iron ores, render it nearly certain that this branch of industry will never receive a check from an insufficient supply of fuel.

Ores of zinc and lead.

In the examination of the strata of which a brief description has been given, small quantities of lead and zinc have been seen, but not in sufficient abundance to be valuable. Mr. Foster, however, discovered a seam, or thin bed, containing a large proportion of sulphuret of zinc, which, it is *possible*, may be profitably wrought. This will be determined by subsequent examinations and chemical analysis. Sulphuret of zinc is sometimes found as the nucleus in nodular iron ores.

There are rumors, in the southern portion of the State, in reference to lead mines, but as yet no veins have been discovered; small quantities of lead have, however, been found in loose masses on the surface. A small piece of this description was recently sent to me from Jefferson township, Jackson county.

Lead must exist in small quantities in either the iron ores or limestones of Lawrence and Scioto counties, as several pounds are, not unfrequently, taken from the crevices in a furnace hearth at the close of a blast*

Notwithstanding these indications, it is believed that there is but little prospect of finding lead in sufficient quantities to be valuable, as rich veins of lead rarely, if ever, penetrate the coal measures; while they are often found in the subjacent limestone.

Geological position of the muriatiferous rocks and salines.

As Dr. Hildreth has given the history of the various salines of the State, my remarks upon this subject will be principally confined to pointing out the geological position of those which have come under my observation.

The determination of the geological position of the strata from which the brine issues, is a matter of high scientific and practical interest, as upon this will depend our success in tracing the muriatiferous rocks, and pointing out situations where explorations for salt water may be made with some degree of certainty.

Water, impregnated with muriate of soda, has been found in all the rocks, from the superior part of the conglomerate down to the great limestone deposite, which is indicated on the profile as underlying the the whole eastern portion of the State. By reference to the plate, it will be seen that these limits embrace the conglomerate, Waverly sandstone series, and the great mass of argillaceous slate or shale, that is immediately superimposed upon the limestone.†

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*This information was communicated by Mr. Smith, of the Jackson Furnace.

†Note. This limestone contains weak brine springs in a few localities; and it is probable that the rocks above the conglomerate, in some places, contain the saline matter necessary to produce them.

In the argillaceous shale (vide C, fig. 4, of the plate) salt water has been obtained in several places by boring; but it was so deficient in quantity and strength that it could not be used profitably in the manufacture of salt. One of these wells was bored in the valley of Paint Creek, about three or four miles west of Chillicothe. Its position is indicated on the profile, to which reference has been made, by the perpendicular line *a a*.

Brine has been obtained in the Waverley sandstone series, by sinking through the conglomerate at the licks in Jackson county, and good water obtained, but not in quantity sufficient to be profitably used in competition with the Kenawha salt wells, in Virginia. The salines at Jackson, early attracted the attention of the western pioneers; and from them, alone, was obtained most of the salt used in the early settlement of the State. They were finally abandoned, in consequence of much stronger brine having been obtained in Virginia. These wells, with the exception of those called "mud wells," were commenced in the superior part of the conglomerate, which, on this account, was denominated the "salt rock."* They varied in depth from 10 to 450 feet, with no sensible improvement in the strength of the brine, except in the deepest, which was bored at the expense of the State; and in this, no difference was observed in the saturation of the water, till the strata had been penetrated 350 feet, when it continued to improve, till the work ceased. Mr. George Crookham, by whom the information in regard to these wells was communicated, says he thinks the brine, at the depth of 350 feet, was equal in strength to that used on the Kenawha, but that the quantity was comparatively small. This well, which penetrates the Waverley sandstone series, is indicated on the profile by the perpendicular line *b b*.

The valuable salt wells on the Hockhocking river, five miles west from Athens, were commenced in the superior part of the series, indicated on the profile by the letter F. The water from these wells is said to be equal, in every respect, to the best wells on the Kenawha, yielding about ten per cent. of salt. These wells are about 430 feet in depth; a distance sufficient to penetrate the conglomerate, and, perhaps, to reach the Waverley sandstone.

All those wells which were commenced in strata in a geological position *below* those before mentioned on the Hockhocking river, are deficient in the strength of the brine. The principal cause of this may be found in the fact, that they were situated so far west, as to be too near the outcropping edges of the muriatiferous strata; in consequence of which, the water, before rising to the surface, could not percolate a sufficient distance through the strata to become thoroughly impregnated with saline matter.

The wells at Jackson, in addition to the disadvantage of having been commenced *too low* in the series, were situated on a stream, the

* The "mud wells" were dug to the depth of 24 to 30 feet, in clay, sand and gravel, which occupy a basin-shaped cavity in the superior part of the "salt rock," at Jackson.—The brine, without doubt, was produced by the percolation of water through the rock into this reservoir.

waters of which run in a direction opposite to the dip, through deep valleys and ravines, which so interrupt the continuity of the strata, that a considerable portion of the saline matter finds its way into the water courses, and flows off in a westerly direction.

From the facts which have been stated, it may be inferred that locations for salt wells, to be the most judicious, should be higher in the series than the conglomerate, and on those streams which flow across the country in an easterly direction, or nearly in the line of dip. And as some of the strongest brine has, probably, been obtained in the conglomerate, the wells should be bored so deep as to penetrate that stratum.

There are other circumstances which influence the quantity and strength of brine, besides those which have been stated. Among these may be mentioned fissures and undulations in the strata, and the relative amount of saline matter in the muriatiferous rocks at different localities; in consequence of which, some uncertainty will always attend boring in search of salt water.

FOSSIL BONES.

As before observed, some of the salt wells in Jackson county were dug in a deposit of clay, sand and gravel, occupying a basin-shaped cavity in the superior part of the conglomerate. In nearly all these wells were found fossil bones, consisting of jaws, teeth, tusks, vertebræ, ribs, &c, which, from the descriptions given by Mr. Crookham, belong to extinct species of animals. From his descriptions, remains of the megatherium, and of the fossil elephant, were among the number. A more detailed description of the bones from these wells, will be communicated at another time.

Mammoth, or Fossil Elephant.

About two years ago, some bones, so large as to attract the attention of the inhabitants, became exposed in the bank of one of the branches of Salt creek, in the northwest part of Jackson county. They were dug out by individuals in the vicinity, from whom we obtained a tooth, a part of the lower jaw, and some ribs.

In the examinations at this place, during the past season, it was concluded to make further explorations, not only with the hope of finding other bones, but with a view of ascertaining the situation, and the nature of the materials, in which they were found. The explorations were successful. There were found some mutilated and decayed fragments of the skull, two grinders, two patellæ, seven or eight ribs, as many vertebræ, and a tusk. Most of these are nearly perfect, except the bones of the head. The tusk, though it retained its natural shape as it lay in the ground, yet, being very frail, it was necessary to saw it into four pieces, in order to remove it.

The following are the dimensions of the tusk, taken before it was removed from the place in which it was found:

Length on the outer curve	10	feet 9	inches.
" " inner curve	8	" 9	"
Circumference at base	1	" 9	"
" 2 feet from base	1	" 10	"
" 4 " "	1	" 11	"
" 7½ " "	1	" 7½	"

This tusk weighed, when taken from the earth, 180 lbs. The weigh of the largest tooth is 8¼ lbs.

These bones were dug from the bank of a creek, near the water, where they were found under a superincumbent mass of stratified materials 15 to 18 feet in thickness. The section, (fig. 3, of the plate,) carefully taken on the ground, will give a correct idea of the arrangement of the materials, and the relative position in which these interesting fossils were found.

No. 1 is a yellowish clay, or loam, which now forms the surface of a swamp about one mile in length, and one-fourth to half a mile in breadth; it is covered with large forest trees, many of which, from their size, must have been growing some centuries—5½ feet.

No. 2. This layer is a yellowish sandy clay—7½ feet.

No. 3 is an irregular layer of ferruginous sand, tinged with shades of red and yellow, and partially cemented with iron—4 to 8 inches.

No. 4 is a chocolate colored clay or mud, the inferior part of which contains the remains of a few gramineous plants, very much decayed—2 feet.

No. 5. Sandy clay, colored, like No. 4, but a little lighter—1½ foot.

No. 6 is the stratum containing the bones. It consists, judging from external characters, of sand and clay, containing a large proportion of animal and vegetable matter—1 to 1½ foot.*

These bones, from their position, had evidently been subjected to some violence before they were covered with the stratified deposites which have been described.

The jaw and grinders, with the other bones which we have thus slightly noticed, evidently belong to an extinct species of the elephant, now found in a fossil state. As the teeth differ from any which are figured and described in the books to which I have access at the present time, it is possible they may belong to an undescribed species.

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*All these layers, with the exception of the ferruginous sand, contain so much carbonate of lime as to effervesce briskly with acids. They will be valuable as manures, on light, sandy soils, deficient in carbonate of lime.

In bringing to a close this abstract account of my labors during the past season, it may be stated that perhaps no part of the world is more productive than will be the entire portion of the State which has this season been partially explored. The *western* portion, embracing the vallies of Scioto and Paint, is almost unequalled in fertility of soil; while the *eastern*, although not so fruitful, contains, beneath the surface, exhaustless stores of mineral wealth. Those counties which have hitherto been considered of so little value for agricultural purposes, are destined to become some of the most wealthy and densely populated in the State.

I cannot close this communication without acknowledging the valuable assistance which has been rendered me by J. W. Foster, Esq., Acting Assistant on the survey. He fully participated in all the labors of the season, and deserves my warmest thanks for the prompt and efficient manner in which he discharged all his duties.

I have the honor to be ,with great respect,

Your obedient servant,

C. BRIGGS, Jr.,

Fourth Assistant Geologist of Ohio.

COLUMBUS, *January* 1, 1838.

REPORT

OF

MR. WHITTLESEY,

TOPOGRAPHER OF THE GEOLOGICAL SURVEY OF OHIO.

No. 5.

To W. W. MATHER, Esq.,
Principal Geologist of Ohio.

By your instructions of the 23d of June last, I am directed to proceed to the region, included between the Scioto and Hockhocking rivers, and construct skeleton maps, of the townships and counties within that district, for the use of the geologists in the field. These maps were to exhibit, "as far as practicable, the lots as originally laid out, and subsequently divided, the courses and meanderings of the streams, and the topographical details of the country adjacent." As this branch of the survey was instituted more particularly with a view to enable the scientific explorer, to locate his discoveries with the greatest possible accuracy, I have executed the instructions "as far as practicable."

From the best authorities within my knowledge, I have constructed plans of townships, for the counties of Jackson, Lawrence, Gallia and Hocking, and for those parts of Scioto, Pike and Ross, lying east of the Scioto river. They are upon a scale of two inches per mile, accompanied by county maps (with the exception of Gallia county,) on a lineal scale of one-half their size. The streams, down to the minutest branches, the civil and mathematical divisions of the territory, the general course of traveled roads, with mills, furnaces and villages, are represented upon them.

The subsequent divisions of the soil, according to present ownerships, are seldom to be found, and are undergoing constant changes. The exact meanderings of the streams can only be obtained by a survey; and more pressing duties have prevented this, with the exception of the south fork of Salt Creek, and part of the Middle fork. In a country so uneven as the river counties, where several independent hills or bluffs occupy each square mile, without any approach to ranges, it is impracticable to locate every irregularity of surface, without a *trigonometrical survey*, or to represent it when located, without greatly enlarging the scale. Moreover, the streams are a true index to the configuration of the country· each water course representing a valley between high lands; and few, or none, however small escape notice.

Original Surveys.

Most of my information is derived from the land offices of the General Government, where all lands sold by the United States, are represented in townships of six miles square, subdivided into parcels of one mile square, containing 640 acres. Where the lines of the original surveys cross a stream over seven links in width, the distance from the last corner, the course and breadth are noted.

Most of the country delineated this season, is within a Congress land district; and those parts lying in the "Ohio Company's Purchase," are represented in the same way; the original allotment having been made by order of Congress, and upon the general principles of the public surveys. The *entire territory* of Ohio, is surveyed according to the same general system, excepting the "Virginia Military Reservation," the "Western Reserve," "Military Bounty Lands," and some small unsurveyed Indian Reserves. Streams considered navigable for batteaux, were surveyed upon both shores, and may be traced with accuracy; but for those of a lesser size, the course between section lines is imaginary.

Highways.

Roads are designated upon the skeleton maps, but only in a general manner. Owing to material variations in the magnetic needle, both by lapse of time, and change of place, the recorded plats of county and State roads run at various times, without system, and without reference to the true meridian, cannot be connected in a geometrical manner with the section lines of the public lands; the latter coinciding with the parallels of latitude and longitude.

The public highways have been established, by ascertaining the names of individuals resident upon the route, and referring to the auditor's books for their location in the proper section or fraction.

A final map of the county of Jackson, is executed in accordance with your directions, embodying, in addition to the geographical details enumerated, the geological information indicated upon the skeletons returned to me. No other entire county has been placed in my hands by the geologists.

Character of the country.

The external characteristics of the county of Jackson, the southeastern part of Ross, and the eastern portions of Pike and Scioto, the only districts to which I have given personal examination, are quite similar. Along the right bank of the Ohio an abrupt bluff, apparently 300 feet high, overlooks a valley from half a mile to a mile and a half in width, fronting a similar range upon the left bank. The Ohio river occupies of this space, at ordinary stages, an average of 1750 feet, or about one-third of a mile, crossing from side to side in ample curves. The bluff is continually broken by the passage of water courses that (however small,) wear their way down through the soft rock of this region, to the level of the river. Consequently, lakes, swamps, and waterfalls are uncommon, notwithstanding the semi-mountainous character of the country. On the left bank of the Scioto, from its mouth at Portsmouth to Chillicothe, a line of steep hills, limits the valley on the east, met by a corresponding elevation on the west. The trough of the Scioto is, however, wider than

the Ohio, being from two to four miles, through which the stream, 25 rods in width, courses at random in a very crooked and irregular manner. The vicinity of both rivers, presents occasional *lagunes;* those on the Ohio much above the general level of its waters, and therefore capable of drainage; while those of the Scioto are not so, being chiefly caused by the absence of the stream from its former bed; and consequently, nearly or quite as low as low-water.

This river, which passes the surplus water of 2600 square miles, rises 15 to 20 feet, at a point of the stream, above where it is influenced by the reflux of the Ohio. Its channel is continually changing; sometimes by the ordinary action of the current upon its alluvial banks, but more often by the force of violent floods, which cut through the necks of land, forming what are there termed "*thoroughfares.*" Previous to the construction of the Ohio Canal, it was the channel of commerce for the produce of its shores; but at all times uncertain, dangerous and expensive. Owing to the want of proper instruments, the elevation of the general surface of the country embraced between the Scioto and Ohio rivers, has not been ascertained; but the summits of the thousand cone-shapen hills that cover its whole territory, seem to lie in one plane, which inclines slightly towards the junction of the two streams. Ascending the Scioto, these hills are less elevated, with reference to the river, and their bases enlarge in proportion. The same is observed, if we go interior from either stream, until at the distance of a few miles the inclination of their sides diminishes, they become capable of cultivation; and when improved, furnish excellent pasturage, especially for sheep. No regularity is perceivable in the location of these knobs, and nothing like ranges in the bluffs, except at the dividing ridges between streams. In the extreme eastern part of Scioto, and I am informed by James Rodgers, Esq., of Hanging-Rock, the northwestern part of Lawrence, there is a *back-bone* or narrow ridge, wherever the water flows away in opposite directions, frequently extending many miles in an unbroken yet serpentine course, at an apparent level, and seldom wider than an ordinary road. An inspection of the county maps, with the endless creeks and minute branches there exhibited, will convey a clear idea of the manner in which this country is intersected, bearing in mind, that all water courses, where there is a permanent flow, lie from one to three hundred feet below the adjacent knobs or bluffs.

Streams.

From the southern part of Jackson county, streams descend in every direction. The south fork of Salt creek northwardly, the Little Scioto and Pine creek, to the south and west, and Symmes' creek eastwardly. Many water courses take their rise along a north and south line, passing a little east of the centre of this county, flowing thence to the middle fork of Salt creek, and to the Big Raccoon.

The united branches of Salt creek reach the Scioto near the south line of Ross county; the Little Scioto empties into the Ohio, seven miles east of Portsmouth; Pine creek three miles higher up; and Symmes' creek five miles east of Burlington, the capital of Lawrence county. These, with Beaver creek, of Pike county, are the principal creeks of the section under consideration. They are excessively crooked, with narrow valleys, attended by high hills. Symmes' creek, Little Scioto, and the middle and south forks of Salt creek, are of some value for hydraulic purposes

but they all possess the same characterists—a sluggish current, high floods, and a deficiency of water.

The main Scioto in the lower portion, is too transitory and unmanageable for manufacturing uses; the Ohio canal however, may receive its waters, and in a measure supply this deficiency.

Jackson County.

Along the middle fork of Salt creek, from its mouth to where it branches, the knobs stand in thick succession upon both sides, at an apparent altitude of 350 and 400 feet; sometimes extending along the bank in an elongated manner, a few hundred yards; but having in general a circular base of about three times the height, and an unbroken slope from the summit down. The most elevated points of this wild region lie east of the south branch of Middle fork, in Washington township. Down the valley of this branch passes the great "Buffalo path," leading from the licks at Jackson, to licks upon the north fork, about thirty miles distant. It is at present distinctly traceable throughout, over hills and across valleys, and pursues the most direct practicable route. The appearance is that of a gully, cut in the soil from one to four feet deep, by a sudden torrent, and partially filled again by the effects of time. There are occasional cavities called "Buffalo wallows," where it is said the animal amused himself in his travels, by rolling and pawing in the dust, like cattle. It appears by a statement of Mr. Edward Byers of Jackson county, that individuals of the Buffalo race have been killed on Raccoon, Symmes' and Salt creeks, within thirty years.

The scenery of Little Raccoon, a branch of Raccoon Creek, is quite similar to the Middle Fork, and equally romantic. About twenty miles of this stream passes through the townships of Clinton, Milton and Bloomfield, comprising nearly its whole length; in size, it is less than the South Fork. Along the latter creek, between Strong's mill and Jackson village, sand-rock bluffs, with mural fronts, rise alternately on each bank, from the edge of the water. The remainder of its course presents a topography similar to the Middle Fork; the knobs, however, are less elevated above its bed; showing cliffs of sand-rock occasionally near the top. At the bridge, two miles southeast of Richmond, high-water mark appears to be fifteen feet from low water; and at a bridge near the mouth of Middle Fork, the inhabitants put the highest flood at twenty feet. The width of South Fork at Jackson, is 35 links; at the bridge spoken of, 60; Middle Fork is 54 links wide where it branches, and 90 at its mouth. The knobs in the northern and eastern part of the county, produce pine timber on their *northern* and *western* slopes, from the peak *two-thirds* of the way down. The other portions are covered with handsome oak. There are 12 saw-mills in this county; *lumber*, *coal* and *tar*, forming its present exports. In early times *salt* was its main product, but none is made there now. Pursuant to its general rule, of May 18, 1796, Congress reserved what was equivalent to a township of six miles square, about the main springs, which includes the village of Jackson; and December 28, 1824, it was bestowed in fee upon the State, for literary purposes, divided into 80 acre lots, appraised and sold, but the avails were small. The salt wells are now considered of no value, and, compared with western lands, the donation was, in other respects, unsaleable.

Timber.

The timber upon the Scioto bottoms, in the lower portions of the valley, is, sycamore, cotton-wood, and black-walnut; of the inclined upland, connecting the bottoms with the hills, a general mixture of western trees, including locust and paw-paw, (and, excepting the chesnut,) the upland is mostly timbered with some, or all, of the varieties of the oak. The intervale of the Ohio produces beech, hickory and maple, with sycamores and elms at the margin of the stream.

Levels.

Respecting the levels you have instructed me to take, under the direction of the active geologist, for the purpose of giving the survey a character of mathematical accuracy, heretofore unknown in the progress of geological investigations, nothing has been done in the field. The instruments ordered from the East were, unfortunately, detained on their route, and did not arrive until the 5th instant, while every exertion, on my part, to procure a level for the purpose here, has failed. In aid of this object, however, I have spent some time in collecting and arranging the results of former surveys made within the State. Had the work of all the Engineers in the employ of the State, and of the various Railroad, Canal and Turnpike Companies, been preserved in an intelligible form, there would have been at this day, very few points of consequence, whose precise altitude, with reference to the Ocean, or the Lake, would not be easily known. Yet, with the records of levels within reach, additional surveys of a few miles, branching from the main lines, will leave nothing to be desired in this respect. The explorations for public, as well as private works, are very seldom connected with each other, where the different lines intersect by natural marks or monuments; nor are other routes noticed on the minutes of the Engineer, as he passed. From this cause, and an absence of vertical sections or profiles, of the early surveys, from the files of the Board of Public Works, it is not often that data can be found, whereby to correct and reconcile perplexing variations that exist in some of the returns; but those discrepancies are confined to the early random lines, and are *too small* to destroy the value, even of *this part* of the collection, in determining the general thickness and inclination of strata. A sheet of projections is constructed, showing, at a glance, the vertical relations of many important points, distributed through all parts of the State, and this will be filled out as the necessary information is obtained. The surface of Lake Erie, 564 feet above tide-water, at Albany, is made the plane of reference. This comparison of heights exhibits almost the entire surface of our territory above the level of the Lake. The Ohio river, at Cincinnati, in its lowest stage, is but 133 feet below (that is, nearer the Earth's centre, than) the Lake's surface. Ascending the river to Portsmouth, it rises 37 feet, being 96 beneath the Lake; to Marietta 94 feet, within two feet of the line or plane of reference; and at Beaver, Pennsylvania, its elevation above the waters of Erie, is 127 feet, according to the best information. The highest annual floods lessen the difference between the river below Marietta and the Lake, about 50 feet, and increase the same as we ascend. But the increase of difference is not equal to the decrease, as each tributary, when all discharge surplus water at the same time, of course gives additional height to its waters; yet the extraordinary inundation of Febru-

ary, 1832, which H. G. Eastin, Esq., an Engineer in the employ of the State of Kentucky, puts at 61 feet in the vicinity of the mouth of Big Sandy, was only one foot higher at Cincinnati. From Beaver to Cincinnati, by river, 420 miles, the descent is 260 feet, or 619-1000ths of a foot per mile. But the fall is not uniform, being greatest in the upper part of the river, thus: From Beaver to Marietta, it is 0,86 of a foot per mile; Marietta to Portsmouth, 0,563; Portsmouth to Cincinnati, 0,359. The upper level of the Canal, in the northern part of Cincinnati, is only 21 feet lower than the Lake; the intersection of Main and Cross streets, Aberdeen (opposite Maysville,) 28; and the sill of the Old Court-House, at Portsmouth, in Market street, (about 100 feet north of Front,) is but 35 feet below the line of reference, made use of on the sheet of projections. The elevations of the bluffs and knobs bordering on the Ohio river, have not been taken this season, for reasons above given. They have an apparent height of 300 and 400 feet above our general standard (the Lake,) leaving only a small portion of the immediate valleys of the Ohio, the Scioto and the Miamies, beneath it. The sill of the Court-House, at Piketon, is above, a few inches less than 8 feet. The "Little Mountain," a singular elevation in Mentor, Geauga county, about 5 miles from Lake Erie, and the highest point in the northeastern part of the State, rises but 5 feet above Somerset, in Perry county, and 40 feet higher than the door-sill of Hillsborough Court-House, in Highland county, in the southeastern section of Ohio. This striking feature of uniformity in the general surface of the State, cannot be more plainly exhibited, than by a tabular statement, drawn from the materials hitherto collected, showing in contrast, some points, remote from each other, but of corresponding elevation above Lake Erie—

Hillsborough, Highland Co.,	560.	Highland, west of Akron,	(same.)
West Union, Adams Co.,	410.	Huron Summit Swamp,	414.
Yellow Springs, Green Co. (Cokely's door sill,)	398.	Portage Summit,	395.
Mahoning Summit Swamp (Champion, Trumbull County,)	342.	Kilbuck Summit Swamp, (Harrisville, Medina county,)	337.
		Olentangy, at Delaware,	278.
St. Mary's, Mercer County, (Canal Level,)	278.	Killbuck, at mouth of Apple Creek, near Wooster,	278.
Scioto, at mouth of Mill Creek,	271.	Newark, Old Court-House door sill,	272.
Columbus, west door-sill, Capitol,	197,5.	Waihonding, at mouth Killbuck,	197.
Sinking Spring, Adams County,	150.	Putnam, Muskingum County,	150.
Scioto, at Columbus Feeder	128,75.	Muskingum, at Dresden,	127.61
		Ohio, at Beaver, Pennsylvania,	127.
Fort Defiance, (Canal level)	98	Cleveland Court-House,	95.

It will be seen that the places compared are similarly situated, i. e, Summits stand in contrast with summits, and streams and places upon them are collated with each other.

Ancient Works.

Pursuant to the liberal spirit, and apparent intention of the act of March 27, 1837, I have inspected the ancient remains within the district embraced in this season's operations, and have sketches and notes of nine

separate works. Further exploration and measurements are necessary, however, to render complete the plan, specification and detailed description of most of them. These plans will exhibit the figure of each ruin, as far as it can be traced upon the ground; the elevation and depression of its embankments and excavations, by means of vertical sections or profiles, and a topographical sketch of the vicinity. A plan of the remains at Marietta is nearly finished, and may serve as a specimen of the general method, according to which, it is proposed to execute the whole set.

Many of these ruins of a lost race, are to this day without a description, while their forms and dimensions are fast disappearing under the operation of the plough and the spade. For it is in the rich valleys of the Miami, the Scioto, and the Muskingum, where the modern agriculturist now cultivates the soil, that an ancient people, more numerous than the present occupants, pursued the same peaceful avocation at least ten centuries ago. And upon the sites of modern towns within these valleys, as at Cincinnati, Chillicothe, Circleville, Piketon, Portsmouth and Marietta, the ancients located *their* cities, of which distinct traces exist. They also occupied many other points upon the rivers named, of which evidences remain too plain to be misunderstood. Large works are found on the Scioto in addition to those first mentioned, in ascending; *first*, between the road and left bank of the river, about five miles south of Piketon, on sections 10 and 11, fractional township, adjoining westerly township 4, range 21, on Vulgamore's land. *Second*, on left shore, a short distance below Kilgore's mill, four miles south east of Chillicothe, sections 2 and 3, town 7, range 21. *Third*, on the road from Chillicothe to Richmond, three miles beyond Kilgore's mill, at Richard Alderson's house. *Fourth*, about thirteen miles north of Chillicothe, near the Canal. On Paint creek, and the Olentangy, near Worthington, similar works are found. Research and inquiry will doubtless develop a connected system of antique structures, upon all the tributaries of the Scioto, and its kindred streams, leading to the Ohio. The interest manifested by the learned abroad, relative to these works, and the hasty and imperfect sketches taken of them by travellers, in addition to a local curiosity respecting our predecessors upon this soil, and the other considerations above named, seem to demand of us, a thorough record of what remains to our observation. A general description will accompany the plans when complete, for which it is proper to reserve observations. But the popular name of "fortifications," bestowed upon these ruins, leads me to state that, I have *seen* none to which the term is applicable. I have examined the extensive works at Marietta, and those more extensive ones at, and in the vicinity of Portsmouth—at Vulgamore's, in Pike county—at Piketon—at Kilgore's, in Ross county, and at Alderson's—with other lesser, and detached works, and can discover in none of them, elements of military strength, or evidences of a warlike intention. The principal enclosures are rectangles, or circles, weak figures, without ditches, made weaker by numerous openings, not only in the sides, but at the corners. The subordinate parts of large works, and the small isolated ones, *sometimes have ditches*, but always, as far as I have seen, on the *inside*, though cases of extensive fossa, are said to exist. The main figure always occupies ground accessible on all sides, and no spring, or receptacle of water, is found *within the walls*. Other equally good reasons might be advanced, why these structures are not adapted, and were not designed, either for attack or defence, under any supposable mode of human warfare.

No portion of Ohio appears to be destitute of ancient tumuli and embankments; the object and origin of which are still, in a great measure, mysterious and unknown. They are said to have been discovered, by uncertain traces along the southern shore of Lake Erie, at Salem, in Ashtabula county—on the Vermillion, near its mouth—and in the vicinity of Maumee river. Caleb Atwater, Esq., the pioneer in antiquarian researches at the west, describes a most ample construction in the vicinity of Newark: one enclosure, containing 40 acres. Also, an irregular figure in section 21, town 7, range 16, Perry county, of the same contents; corresponding in this respect, with the large square work at Marietta. The same author has given the details of a circular and square structure in Circleville, attached to each other—of an interesting and extensive remain on the Little Miami river, in Warren county, a few miles above the mouth of Todd's Fork; and some lesser works. Similar ruins are spoken of on the left bank of the Great Miami, five miles from its mouth—on the hill, two miles from Hamilton upon the right bank—and in the vicinity of Dayton and Piqua. Others are said to be known on the Little Miami, near Milford—near Deerfield—at the upper part of Round Bottom—and at the sources of East Fork. In the neighborhood of Athens—at Cats creek, Washington county—in Belpre, in the same county—near Jackson Court House, on sec. 19, town 7, range 18—and on the Ohio Canal, west side, above the mouth of Pond creek Entry 1,270, Virginia Military Reservation,—distinct enclosures, of various and fantastic forms, still remain. The evidences of remote population and labor, now apparent within the State of Ohio, will, when collected in one mass, surprise all who have not bestowed attention upon the subject of Western Antiquities.

Repetition of Names.

There are in this State, thirty-five townships and villages called Washington, twenty-nine named Jackson, twenty-one Monroe, the same number of Waynes, nineteen Franklins and Madisons, sixteen Jeffersons and thirteen of the name of Harrison. Many less extensive repetitions might be added, and every year increases the number. The counties of Fairfield, Franklin, Pickaway, Fayette, Perry and Highland, all immediately adjoining, are each furnished with a township called Madison; and it will be seen that almost one half of the counties in the State contain a Washington. Great complaint is made of irregularity and delay in the reception of intelligence by mail, at interior post-offices, much of which is traced to unavoidable errors in the direction of packages, arising from this multiplicity of identical names.

Survey of Streams.

The present opportunity is favorable, to the meandering of all streams of a less magnitude than those called navigable, (and already surveyed and recorded by the public surveyors,) but large enough to be of importance for hydraulic purposes; say down to a width, at ordinary stages, of 50 links. Or at least the water courses, Lake shore and marshes covered with water, in the "Virginia Military Reservation," the "Western Reserve," and parts of the "Military Bounty Land." Many streams of the second class, are already traced, in connection with the public works, and plans are returned to the office of the Board.

It is well known that the Virginia Military Land Warrants, were located without any previous survey, with the exception of a tract north of the Indian Boundary, established at Fort Greenville in August, 1795. All the country between the Little Miami, the Scioto and the Ohio, was dedicated to these warrants; and aside from the tract just mentioned, (and the still unlocated and waste portions of at least 200,000 acres,) the whole district is subdivided into irregular parcels, according to the fancy and interest of the proprietor.

Previous to the "Deeds of Cession," much land had been entered at the Virginia offices, of which the surveys were discordant, incomplete, and not fully returned. Little more system has prevailed in the greater part of the subsequent selections; and the special office for that district, at Chillicothe, now under the control of the United States, is unable to furnish a true map of the lot lines, much less of the interior streams. In this connexion, another important matter presents itself, in reference to the Virginia Reservation. A custom has prevailed of "locating," by extending the corner monuments, *more acres* than the warrant specified; *land marks*, controlling course, distance and quantity. The whole tract is entered, and taxed, from the description in the warrant. If subsequent sales are made of portions of the entry, the deed commonly shows the true quantity transferred, and the proprietor who retains the balance, is taxed for the difference only between the deed and the warrant. Great inequalities arise in this way, in the *taxation of property;* and where a county is composed in part of Congress lands, whose quantity is known, and partly of Virginia Military Lands, the inequality assumes a sectional character. It has been strongly represented, that justice and policy require a resurvey of the warrant entries, either at the expense of the county, or State, in order to equalize taxation. This work would locate the streams, and supersede the necessity of the partial survey suggested. It is not in my power, at present, to give the expense of a resurvey of the entries; but an idea of the importance of it may be drawn from the imperfect statement which follows, and also from the fact, that an offer was made by a Surveyor, some years since, to the Commissioners of Franklin County, to resurvey that part within the Military District, in consideration of an assignment of the taxes upon the overplus, for five years. A computation, made by the aid of township maps, in the office of the County Auditor, gives 136,396 acres, as the contents of Franklin County, west of the Scioto. The quantity returned for taxation on the duplicate, is 120,249, leaving 16,147 untaxed. By a law, directing the survey of a portion of the boundary of Clinton County, it is to be run so as to give the constitutional territory 400 square miles, or 256,000 acres, and this County returns but 246,657 for taxation. E. P. Kendrick, Esq., who is connected with the Virginia Reservation Office, at Chillicothe, says, "We consider the District lying North of a line West from this place, entirely taken up and located. Most of the vacant land is in Pike, Scioto and Adams; there is some in Clermont, Highland and Brown, and the South part of Ross."

The Reservation embraces eight entire Counties, with considerable portions of ten more. On the supposition, that the parts of Scioto, Pike and Ross, are equivalent to all the *unlocated* lands in the District, and that the remaining fractional Counties are equal to four complete ones, we have twelve counties of land, where the excess, whatever it may be, escapes taxation. The average quantity of real estate exempt, according to the rough calculation above, combined with an uncertain estimate in

Pickaway County, is about 16,000 acres per County, or 192,000 acres in all, if the data can be relied upon. Thus, one-eighty-fifth part of the taxable land of the State is relieved from its share of the public burdens, and mostly for the benefit of non-resident proprietors.

The "Bounty Lands" being all *North* of the North line of Township 8, Range 8, West of the Pennsylvania line, produced, westward, to the main Scioto, (two miles North of Columbus,) *East* of Scioto, *South* of the Greenville treaty line, and *West* of the West line of the "Seven Ranges," was surveyed, by order of Congress, into blocks or townships of five miles square, which were quartered, making tracts of 4,000 acres, through which no lines were run. A small portion was then cut into 100 acre lots, and recorded; but the private subdivisions, if on record in the counties, seldom notice the streams. In the "Western Reserve," lying between a line, extending 120 miles West from the Pennsylvania line, on the 41st parallel of North latitude, and Lake Erie, the Federal Government never held proprietary rights. Here, the township lines were run at intervals of five miles, and, according to the true meridian; but the subordinate surveys are without similarity, save that the lots are generally rectangular; the streams being seldom, or inaccurately noted. The "Ohio Company's Purchase," and the "Symmes' Purchase," are allotted as Congress lands; but, even under that method, the creeks escape observation between section lines.

Unsurveyed Shore.

The Ohio Canal, as finally located, will require to be meandered in many parts, before it can be laid down in proper connection with lot or section lines; and parts of other works may be found in the same condition. By a statement of Samuel Williams, Esq., Chief Clerk in the Surveyor General's Office, Cincinnati, it appears that the Ohio river, from the mouth of Little Miami to Portsmouth, 100 miles, and along the Ohio Company's Purchase, about 120 miles, has not been meandered.

The shores of Lake Erie and Sandusky bay, East of the West line of Huron County, have not been accurately determined. The amount of stream, over 50 links wide, as yet unsurveyed, cannot be estimated with accuracy. In the Western Reserve, there would be, including Lake Erie and interior Lakes, from 150 to 200 miles of shore, per county. The other counties would average from 100 to 150 miles of water course, exclusive of the Ohio, of which a full survey is in progress, under the care of Lieut. John Sanders, of the Engineer corps. Unless the Geological examinations be expedited, in the coming season, so as to render an Assistant necessary, the increase of expenditure for this work will be trifling. In any event, the additional cost, in fact the entire expense of the topographical branch of the survey, may be easily refunded, and the citizens of the counties greatly commoded by the publication upon a suitable scale of the manuscript county maps, constructed for the geologists.

I cannot close, without a public reference to the universal kindness and hospitality, manifested by the citizens, with whom I have been brought in contact the past season, and especially to the marked politeness and readiness exhibited by those gentlemen connected with the Public Offices, of all kinds, in affording every facility for information connected with the survey.

CHAS. WHITTLESEY,
Topographical Surveyor.

COLUMBUS, *January* 6, 1838.

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No. 6.

GEOLOGICAL QUERIES.

A geological survey of the State of Ohio has been commenced, in compliance with an act of its Legislature.

With a view to facilitate the progress of the survey, the following queries are propounded to the people of the State, hoping that every one who is interested, either in having the mineral wealth of his farm known, or in advancing geology and its kindred sciences, will contribute such aid as may be in his power. The local knowledge of individuals may be of great importance in expediting the survey.

We would suggest to proprietors of estates, that they forward to Columbus specimens of the minerals, rocks, petrifactions, and soils, to illustrate the nature of the materials of their lands. The mineral wealth, as well as the agricultural value of a farm, should be known, before a correct estimate of its worth can be formed. Our land owners are more immediately interested in the geological survey, than any other class of the community, and they will appreciate the importance of having the mineral products of their land represented in the State Cabinet.

Individuals and associations are requested to lend their aid in advancing their own, and the public interests. Boxes may be sent, directed thus:

W. W. MATHER, S. G.

Care of Jos. Ridgway, jr.

Columbus, Ohio.

Letters should accompany the boxes, or be sent by mail, describing them. A concise abstract of general directions for selecting geological specimens, and observing geological phenomena, will be found at the end of the queries.

Letters from the various parts of the State, containing local information upon any subjects embraced in the queries, may be addressed to

W. W. MATHER,
STATE GEOLOGIST, *Columbus, Ohio.*

Rocks.

1. Have *ledges* of rock been observed in your vicinity?
2. Are the ledges on the sides, or on the summits of hills; on the shore, or in valleys?
3. Are the rocks divided into regular layers?
4. Towards what point of the compass do these layers pitch with the greatest declivity?
5. Are there veins of other rocks traversing those before mentioned?
6. In what direction do these veins cut through the rock, and are they perpendicular, or inclined?
7. Have any ores been found, either diffused through the mass of rock, or in separate beds or veins?
8. Have any useful, or curious, or rare minerals, been found in the rocks or veins?
9. What names are commonly used to designate the rocks, ores, minerals, &c., referred to?
10. Have they been applied to any useful purposes?
11. Where ledges of rock have been recently uncovered by excavations, are the surfaces smooth, as if by the action of running water, or with pot holes, such as are seen at many water falls?
12. Do any of these surfaces show grooves and scratches, as if hard masses had been dragged over them?
13. Do the rocks recently uncovered show traces of the shells of barnacles, or other marine remains, attached to them, in sheltered situations, and much above the level of the sea?
14. Are shells or petrifactions of any kind, or the remains of plants, ound in any of the rocks, and in what kinds of rocks do they occur?
15. Do the rocks which are exposed at the surface, or buried at moderate depths, show any tendency to disintegration or decomposition?
16. Are rocks found to be decomposed, in their natural situation, (in situ,) into stratified clays, sands, loams, gravel, &c.?
17. What is the texture of the rocks; porous, like sandstone, or compact and impenetrable by water, like compact limestones; slaty, or granular, or crystalline like granite and some marbles?
18. Do the rocks indurate, or become harder and stronger, after removal from the quarry?
19. Are saline substances, such as salt, alum, copperas, nitre, gypsum, &c., seen efflorescing on the surfaces of the disintegrating rock?
20. Where water carries off the efflorescing saline substance among the leaves of oak and other trees, are the leaves or water changed in color?
21. Are slate, limestone, sandstone, granite, gneiss, &c., found in your vicinity?
22. Where rocks of different kinds come in contact, is there any change in their characters near their junction?
23. Do the rocks show distinct lines of demarcation, or do they gradually blend into each other?

24. Where fissile stratified rocks occur, are the laminæ parallel to to the strata?

25. If the laminæ be not parallel to the strata, is there any regularity in the angle of inclination of one to the other?*

Sands.

1. Are there any beds of fine white sand, or sandstone, which contain no black, or red, or yellow grains?
2. Has it ever been used for making glass, or for other purposes?
3. Are there beds of red, or black sand, washed upon the beach of the lake?
4. Are these sands abundant enough for purposes of commerce?
5. Have they ever been used as iron ores, or as a substitute for emery, or for blotting sand?
6. Do any of the metallic sands yield a bright red powder?
7. Is the general surface of the country sand, clay, or loam?
8. Do these materials form alternating regular layers?
9. Does the sand on the surface of the country drift by the wind?
10. Have any farms been thus materially injured?
11. Have buildings, trees, hedges, fences, or wells, been covered from this cause, or marshes or ponds made dry land?
12. Do the sands progress in any particular direction, and at what rate per annum?
13. Is the sand, in any locality, hardened into a sandstone?
14. Is sand washed along the shore by currents, and deposited in new situations?
15. Are any islands, sand bars, spits, shoals, or beaches, known to have been thus formed?
16. Have islands been connected with each other, or with the main land, by bars, spits, or beaches?
17. Have islands, or coasts, been washed away entirely, or in part, by the action of the waves?
18. Where cliffs have been undermined, and have tumbled down, what kinds of earth or rock were exposed?
19. Were they arranged in layers?
20. Were bones, shells, bits of blackened wood, leaves, or seeds, or any vegetable matter, imbedded in them?

Clays.

1. Are any beds of clay known in the vicinity?
2. Are the beds extensive, or of small magnitude?

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*The sedimentary sandstones, at the Grotto of Plants, near Marietta, show the character referred to, with all the varieties of interlineated trata which are so frequently observed in the tertiary and alluvial sands.

3. At what depth do they lie below the surface?
4. What is the thickness of the bed or beds?
5. What materials were observed in digging down to them?
6. Are the clays in thin layers, which easily separate?
7. Do the beds of clay alternate with beds of sand and gravel?
8. Are the layers of the beds of clay, gravel, or sand, inclined, or are they level or undulating?
9. What is the color of the clay?
10. Is it mixed with sand, or is it free of grit?
11. When mixed with water, does it form a tough and plastic mass, or does it crumble to a pap?
12. When heated red hot, does it become red, brown, or white?
13. To what useful purpose has it been applied?
14. What quantities are annually exported, and for what purposes?
15. Has it been tried as a manure for sandy soils?
16. Do balls or flat rounded masses of a hard earthy mineral occur in the clay?
17. Are they arranged in layers parallel to the layers of clay?
18. Are they of the same materials as the clay?
19. At what depth from the natural surface are they found?

Water springs, &c.

1. At what depth is water obtained?
2. What strata are passed through before reaching it?
3. Does clay, loam, or rock occur at the level of the springs?
4. Is the water "hard," or "soft," as these terms are usually employed when speaking of water?
5. Did the water percolate gradually into the well, when first dug or did it come in a strong stream?
6. Have shells, bones, pieces of blackened wood, or common wood, beds of marl or clay, been observed in digging wells or cellars, or by the caving down of cliffs or banks on the shore or by the sides of streams?
7. Have mineral springs been discovered?
8. What is their taste: sulphurous, inky, pungent, or saline?
9. Is there any sensible odor to the water? What is it like?
10. Is the water sparkling, like bottled beer; and does air bubble up from the fountain?
11. Is there a reddish or yellowish deposite where the waters flow off, or in the adjacent meadows or ponds; or is there a similar oily scum on the water?
12. Do sticks, mosses, leaves, &c., become incrusted with or imbedded in a hard stony coat, or is there a gray or yellowish rock forming near the spring by a deposite from the water?
13. Where such rocks are formed, are leaves, sticks, reeds, grasses, land shells, or pebbles found imbedded in the concreted rock; or have these substances decayed and left their moulds or impressions repre-

senting the exact form of the body originally imbedded; or is the original body petrified, and converted into stone, but still showing its organic structure; or are they casts representing the exterior forms but not the organic internal structure?

14. Do such masses of rock descend the hills from the location of the springs, forming a mass of rock different in appearance from the common rock of the country around?

15. Where such masses of rock encounter a stream, are they continued across it, or are they found to stop short, forming overhanging cliffs, with pedulous masses of the same material hanging from the cliff, like icicles and stalactites?

16. Has the mineral water been used in the cure of any diseases?

17. Is the spring copious?

18. Do large springs burst from the earth?

19. What is the temperature of the springs.

Salt springs and licks.

1. Are any salt springs or licks known in your vicinity.

2. Did the salt water flow there originally, or is it owing to salt wells having been bored through the rock?

3. Has a record of the strata, with their thickness, or a suit of specimens to illustrate their nature, been preserved?

4. At what depth has the salt water been found?

5. Does it flow at the surface, or is it pumped up?

6. What is its strength?

7. What is the mode of manufacture?

8. Are any difficulties encountered in making good salt, and what are they?

9. What impurities are in the brine?

10. How are they separated?

11. What is the temperature of the water as it flows from the well?

12. Do petroleum, or mineral oil, and tar flow with the salt water?

13. Does carburetted hydrogen issue from the licks and wells by constant bubbling up, or rush up in paroxysmal eruptions?

Subterranean forests.

1. In digging wells, or other excavations, or by the caving down of banks or cliffs of earth, have any traces of trees, wood, bark, leaves, nuts or seeds been discovered much below the surface of the earth?

2. Were these remains in their natural state, or were they converted to stone, or to a black substance like charcoal?

3. If the latter, has the substance been used for fuel?

4. At what depth does it lie, and in what earth, (sand or clay?)

5. What strata were observed above and below?

6. Do the trees stand erect?

7. Do they lie all in one direction?

8. Do you suppose drifting sands, washing by water, or other causes, have buried them?

9. What is the situation of this lignite, with regard to the water courses, and its relative height or depth above or below them?

10. Have shells or bones been found in the layer containing the lignite, or in the adjacent strata?

11. What is the color of the adjacent clay, sand, or gravel?

12. Have masses of a heavy, yellow, metallic stone (pyrites) been found in the adjacent clay, and has it been applied to use?

Peat bogs and shell marl.

1. Are there inland meadows or swamps in your vicinity that tremble when one walks over them?

2. Are they covered by moss and cranberry vines?

3. To what depth can a pole be thrust down?

4. How many are there, and of what extent, in your vicinity?

5. Does the peat, or black tremulous mud, rest on sand, gravel, rock, or a white clayey marl, containing small shells?

6. Has the peat been used for fuel, or for burning lime or bricks?

7. Has the peat, or shell marl, been used as a manure?

8. Are there lakes or ponds, which have a white earthy substance (marl) in them, which contains small shells?

Bog Iron Ore.

1. Are there ponds or marshes in the vicinity, in the bottom of which is a soft spongy, yellowish brown stone or gravel?

2. Does it originate from mineral springs, or from stagnant waters?

3. Does such ore occur in banks on the sides, or at the base of hills, in valleys, or in streams?

4. Has it been used an as iron ore?

5. Is it in such quantities as to be useful?

Marshes.

1. Have the marshes on the borders of lakes, on the banks of streams, or on the flat table lands in your vicinity, changed materially within the period of history, or within the remembrance of old inhabitants?

2. Have they become more wet, and risen so as to cover land before dry?

3. Have they sunk in level, and from what cause?

4. Have they become more dry, and from what cause?

5. Have they changed in the natural growth of the soil?

Lakes and Drainage of Lakes.

1. Has there been a periodical variation of level on our Lake coast, the rise and fall of which has occupied a series of years?
2. Is Lake Erie now at a higher or lower level than it was a few years ago?
3. If so, what is supposed te be the cause?
4. Is there a tidal swell on the lake, and which is distinct from the irregular flux and reflux caused by the changes in the direction and force of the wind?
5. Are changes now being effected on the lake coast, either by wasting away, or by the formation of new land?
6. To what cause do you attribute them?
7. In what localities are such changes going on?
8. Are there any evidences of the lakes in your vicinity having once occupied a higher level than they do at present?
9. Does this evidence consist in elevated beaches, or the cutting down of their outlets, or both these combined?
10. Are there valleys which seem to have been once lakes, and what evidence is there on this point?
11. Are there regular stratified deposits of clay, sand, gravel, &c. in the valleys?
12. Are there terraces in the valleys, indicative either of ancient beaches, or of such slopes as are formed by the retiring surge on sandy coasts?
13. Are remains of plants or animals found in them?
14. In the gorges at the outlets of lakes, or along the courses of the streams which flow from them, are there marks to show the wearing action of water much above its present level?
15. Are there deep defiles through the country, through which the water flows, or seems to have once flowed?
16. What is the nature of the strata of those defiles, and generally of the country at any of the particular localities, to which you may have referred?

Rivers and River Alluvions.

1. Are the rivers and streams in your vicinity, deepening their channels, or raising their beds by the deposit of alluvial matter?
2. Do you know of instances of lateral streams bringing in such uuantities of alluvial matter, and of so coarse a texture, that the larger stream is unable to sweep it away, and which might cause the formation of lakes in the valleys above?
3. Are the rivers or smaller streams lost by sinking in the ground?
4. Do the flats of ooze and of sand along our rivers increase in magnitude, or rise in their level, in any perceptible degree?
5. To what cause do you attribute it?
6. Has the increase been more rapid of late years than formerly?

7. Are alluvial islands of sand, or of ooze, or shoals and flats of the same, washing away?

8. Do the flats, shoals, or islands near the mouths of rivers and streams increase sensibly in magnitude?

9. What is the mean quantity of water passing through ——— river per day?

10. What relative and absolute quantities of matter are held in solution, and what in suspension, during low stages of water, and during freshets?

11. Is the transported alluvion of rivers deposited in shoals, bars, and islands near their mouths?

Rolled masses, pebbles, and erratic blocks.

1. Are any large rounded or irregular masses of rock found in your neighborhood?

2. Do they occur mingled with gravel and pebbles, or are they isolated on the surface, or imbedded in the earth?

3. Do they crumble away by the effects of the weather?

4. Are they smooth, or nearly so, like pebbles?

5. Are there scratches on them, in one or more directions?

6. Are there ridges on them in one direction only, from the harder points of the stone, and parallel to the scratches?

7. Are these rounded pebbles all of one kind of rock?

8. Do these boulders or blocks occur singly, or are they in groups?

9. What rock or rocks constitute these masses and pebbles?

10. Are they similar to ledges of rock known to you, either in the vicinity or elsewhere?

11. Are barnacles, or other shells, or the remains of marine animals, observed on them when they are at a distance from the sea or buried in the earth?

12. Has ice been known to move masses of rock in ponds, streams, bays or inlets?

Elevation of land.

1. Are there beds of rock containing remains of animals or plants whose proper habitat is the ocean?

2. Are the rocks horizontal or inclined?

3. Are they bent, contorted, or are they dislocated?

4. What is the direction of the line of bearing of the strata?

5. Is there any evidence that the rocky strata have been elevated at one or at several epochs? If at one epoch, all the strata are conformable up to the time of its occurrence, unless in the rare case of elevation without derangement of the dip. If at several, the strata formed subsequent to each of these epochs are successively unconformable to those below, with the same exception as above.

6. Are the axes of elevation parallel, or do they intersect, and what are their directions?

7. The occurrence of anticlinal and synclinal lines, and their directions, should be particularly noted.

8. Are the rocks intersected by regular fissures parallel to each other, and dividing them into large masses?

9. Are there two or more systems of these fissures, uniform in direction in each system?

10. Are these systems of fissures vertical or inclined, and towards what points of the compass do they trend?

11. Are they uniformly smooth, with a plane surface, as if cut through with a saw?

12. Can faults be traced along the base of steep escarpments of rock, where streams or artificial excavations expose transverse sections of the strata?

13. Can dykes, or masses of trapean or other igneous rocks, be traced along the line of fault, or of any up-heave of the strata?

Agriculture, manures, &c.

1. What manures are employed on the soil

2. Has a rotation of manures been tried?

3. What rotation of crops is employed on the light, and what on the heavy soils?

4. Have changes of rotations of crops been tried, and with what success?

5. How are your manures prepared?

6. Does lime, or ashes, or marl, or gypsum, or barilla, enter into the composition of the compost heap?

7. Has salt, or nitre, or copperas been tried in small quantity on the land as manure?

8. Has the black ash of the soap boilers, or the bitter water of the salt makers, been used as a stimulant manure?

In very small quantities they would undoubtedly be beneficial.

9. Have shells or pounded limestone, or limestone gravel, been strewed upon the soil with a view to their action as a permanent fertilizer?

10. Has limestone or any other rock been ground and used as a manure?

11. Has peat been rotted and tried as a manure?

12. Has pond-hole mud been tried?

13. Have clay soils been dressed with sand, sand soils with clay, and marshes with gravel or sand?

14. Are banks of shells known, except such as have been left by the Indians, and which are either superficial or buried by a small depth of turf, drift sand, or earth washed over them where the water flows?

Caves.

1. Are there caves in the vicinity, and in what kind of rock?

2. Do they appear to have been once fissures, and so symmetrical

on the sides that if brought together, the salient parts of one side would fit into the reentering parts of the other?

3. Are the sides and roof adorned with stalactites of a white, gray, or yellow color, hanging in pendulous masses, like icicles or drapery?

4. Is the bottom of the cave covered with stalagmite, and is it of such a color or transparency and beauty as to be fitted for an ornamental marble?

5. Do streams of water pass through the caves?

6. Do the internal parts show arched passages worn smooth, as if by the action of flowing water?

7. Have bones been found in the earth in the bottom of the cave?

8. Are they similar to those of existing animals?

9. Has the stalagmitic crust (which covers the bone earth in many caves) been penetrated in search of bones?

10. Have remains of human art been found in similar situations?

Are there subterranean streams, land-slips, sink-holes, (formed by the sinking down of small tracts,) rocking stones, natural ice-houses, or curious or interesting natural phenomena of any kind which have come under your observation, and which are not embraced in the preceding queries?

Suggestions for collecting Geological Specimens, and observing Geological Phenomena.

1. Collect specimens of all those rocks, earths, sands, clays, peats, marls, and lignites observed, and note the relative quantities, whether abundant or rare.

2. If any of those materials be applied to useful purposes, note their particular applications, the places where used, the amount of industry and capital employed, and the articles produced.

3. If they be not used, note whether, in your opinion, any one, or all, may be usefully applied, and for what; and what facilities the adjacent country may present for manufacture or transport, or from its contiguity to a market.

4. Note the order of superposition of the different beds of rock, earth, sand, clay, &c., with regard to each other; the amount and direction of the dip; whether dislocations or faults, dykes, veins, &c. traverse the strata, and the direction and inclination of these dislocations, veins, dykes, &c. Sketches should generally be made to illustrate the thickness and relative position of strata, particularly if they be contorted.

5. Note if any traces of organic existence be observable in any of the materials mentioned, whether animal or vegetable, either as impressions, casts, or petrifactions; whether imbedded or loose in these materials.

6. The excavations in mining, quarrying, cutting canals, rail-roads, &c., offer particular facilities for observing the phenomena of stratification, of the superposition of rocks, &c.

7. In boring for coal, salt springs, &c. it is hoped that specimens of

the rock, clay and sands, of every foot in depth passed through, will be preserved, and accurate minutes made in writing, on the spot.

8. In deep wells, mines and salt springs, the temperature of the water should be measured as it issues from the strata.

9. The temperature of copious springs should be measured, noting if it be different at different seasons of the year.

10. In mines, is there a local variation of the compass, and are there evidences of the passage of electrical currents?

11. What is the mean temperature of the bottom of the mine, and of the rocks at the ends of the levels, at such a depth as to be beyond the influence of the heated air of the mine?

12. Specimens to illustrate the various kinds of minerals, rocks, clays, marls, peats, &c. should generally be about two by three, or three by four inches, and one to two inches thick, of a rectangular form, and free from hammer-marks and weathering.

13. Fossils, or rock specimens containing fossils, must be taken of such a size, as may be necessary to illustrate to the best advantage; still, where fossils are imbedded in stone, much taste may be displayed in getting them out with a good shape, and free from hammer marks.

14. The occurrence of bones, tusks, teeth, shells, &c. where wells, cellars, canals, roads, &c. have caused excavations to be made, should be particularly noted.

15. Every specimen from the same *stratum* at any *one locality*, should be similarly marked.

16. Each specimen should be wrapped securely in a separate paper, and packed tightly in a box, so that it may not be rubbed and injured by transportation from one part of the country to another.

17. It is important that rock specimens and fossil remains should be taken from ledges of rock in their natural position, and not from loose masses.

15. Soils should be taken from a depth of about 8 inches below the surface.

19. The names of the county, township, and land owner, should be distinctly marked on a small label, which should be enclosed in the wrapper of the specimen.

W. W. MATHER,
Principal Geologist of Ohio.

GLOSSARY

OF SOME

GEOLOGICAL TERMS USED IN THESE REPORTS,

FROM

LYELL'S GEOLOGY AND OTHER SOURCES.

No. 7.

Alluvial. The adjective of Alluvium.

Alluvion. A synonim of Alluvium.

Alluvium. Recent deposits of earth, sand, gravel, mud, stones, peat, shell banks, shell marl, drift sand, &c., resulting from causes now in action. This term is generally applied to those deposits in which water is the principal agent.

Alum rocks. Rocks which, by decomposition, form Alum.

Amorphous. Bodies devoid of regular form.

Amygdaloid. A trap rock which is porous and spongy, with rounded cavities scattered through its mass. Agates and simple minerals are often contained in these cavities.

Anthracite. A species of mineral coal, hard, shining, black, and devoid of bitumen.

Anticlinal. An anticlinal ridge or axis is where the strata along a line dip contrariwise, like the sides of the roof of a house.

Arenaceous. Sandy.

Argillaceous. Clayey.

Augite. A simple mineral of variable color, from black through green and gray to white. It is a constituent of many volcanic and trappean rocks, and is also found in some of the granitic rocks.

Avalanche. This term is usually applied to masses of ice and snow which have slidden from the summits or sides of mountains. It is now also applied to slides of earth and clay.

Basalt. One of the common trap rocks. It is composed of Augite and feldspar, is hard, compact, and dark green or black, and has often a regular columnar form. The palisades of the Hudson show the columnar aspect of trap rocks. The Giants' causeway is cited as an example of Basaltic rocks, and the columnar structure is there very strikingly displayed.

Bitumen. Mineral pitch, which is often seen to ooze from fossil coal when on fire.

Bituminous Shale. A slaty rock, containing bitumen, and which occurs in the coal measures,

Blende. Sulphuret of Zinc. A common shining zinc ore,

Bluffs. High banks of earth or rock with a steep front. The term is generally applied to high banks forming the boundaries of a river, or river alluvions,

Botryoidal. Resembling a bunch of grapes in form.

Boulders. Rocks which have been transported from a distance, and more or less rounded by attrition or the action of the weather. They lie upon the surface or loose in the soil, and generally differ from the underlying rock in the neighborhood.

Breccia. A rock composed of angular fragments cemented together by lime or other substances.

Calc Sinter. A German term for depositions of limestone from springs, and waters which contain this mineral in solution.

Calcareous rocks. A term synonimous with limestones.

Calcareous Spar. Crystallized carbonate of lime.

Carbon. The combustible element of coal.

Carbonates. Chemical compounds containing carbonic acid, which is composed of oxygen and carbon.

Carbonic Acid. An acid gaseous compound, incapable of supporting combustion, and deleterious to animal life. It is common in caves and wells, and many incautious persons loose their lives in consequence of descending, without first ascertaining its presence by letting down a lighted candle. Man cannot live where a candle will not burn freely.

Carboniferous. Coal bearing rocks. This term has been applied to formation belonging to an ancient group of secondary rocks which contains coal. The term is now used in a more enlarged sense, and may be applied to any rocks containing coal.

Chert. A siliceous mineral, approaching to chalcedony, flint and hornstone. It is usually found in limestone.

Chlorite. A soft green scaly mineral, slightly unctuous.

Chloritic Slate. Slate containing chlorite.

Clinkstone. A slaty feldspathic or basaltic rock, which is sonorous when struck.

Clearage. The separation of the laminae of rocks and minerals in certain constant directions. They are not always parallel to the planes of stratification, but are often mistaken for them.

Coal formation. Coal measures. These terms are considered synonimous, and refer to the great deposit of coal in the older secondary rocks, which has been called the "independent coal formation." There are, however, deposits of carbonaceous matter in all the geological periods, and several of them might also be called coal formations.

Conformable. When strata are arranged parallel to each other, like the leaves of a book, they are said to be conformable. Other strata lying across the edges of these may be conformable among themselves, but *unconformable* to the first set of strata.

Conglomerate, or Puddingstone. Rocks composed of rounded masses, pebbles and gravel cemented together by a siliceous, calcareous, or argillaceous cement.

Cretaceous. Belonging to the Chalk formation.

Crop out and out crop. Terms employed by Geologists and Mining Engineers, to express the emergence of rock, in place, on the surface of the earth at the locality where it is said to crop out.

Crystalline. An assemblage of imperfectly defined crystals, like loaf sugar and common white marble.

Delta. Alluvial land formed at the mouths of rivers.

Denudation. A term used to express the bare state of the rocks over which currents of water have formerly swept, and laid the rocks bare, or excavated them to form valleys of denudation.

Deoxidize. To separate oxygen from a body.

Dykes. A kind of vein intersecting the strata, and usually filled with some unstratified igneous rock, such as granite, trap or lava. These materials are supposed to have been injected in a melted state into great rents or fissures in the rocks.

Diluvium and *Diluvion.* Deposits of boulders, pebbles, and gravel which many geologists have supposed were produced by a diluvial wave or deluge sweeping over the surface of the earth.

Dip. Where strata are not horizontal, the direction in which their planes sink or plunge, is called the direction of the dip, and the angle of inclination, the angle of dip.

Dolomite. A magnesian limestone belonging to the primary class. It is usually granular in its structure, and of a friable texture.

Dunes. Sand raised into hills and drifts by the wind.

Earth's Crust. The superficial parts of our planet which are accessible to human observation.

Eocene. The strata deposited during the oldest of the tertiary epochs, as, for example, the Paris Basin.

Estuaries. Inlets of the sea into the land. The tides and fresh water streams mingle and flow into them. They include not only the portion of the sea adjacent to the mouths of rivers, but extend to the limit of tide water on these streams.

Exuviæ. In Geology, fossil remains.

Fault. A dislocation of strata, at which the layers on one side of a dyke or fissure have slidden past the corresponding ones on the other. These dislocations are often accompanied by a dyke. They vary from a few lines to several hundred feet.

Feldspar. One of the simple minerals, and, next to quartz, one of the most abundant in nature.

Ferruginous. Containing iron.

Fluviatile. Belonging to a river.

Formation. A group of rocks which were formed during a particular period, or which are referred to a common origin.

Fossils. The remains of animals and plants found buried in the earth, or enclosed in rocks. Some of these are but slightly changed, others are petrified and the organic replaced by mineral matter; some have decayed and left the impression of the bodies, while others have been formed by mineral matter deposited in the cavities left by the decay of the organic body. These last are called *casts.* The term petrifaction is applied to those cases in which organic matter has been replaced by mineral substances. The form and structure of the original body both remain. In casts the exterior form alone is preserved. Fossils are also called organic remains.

Fossiliferous. Containing organic remains.

Galena. An ore of lead composed of lead and sulphur.

Garnet. A simple mineral, which is usually red and crystallised. It is abundant in most primitive rocks.

Gneiss. A stratified primary rock, composed of the same materials as granite, but the mica is distributed in parallel layers, which give it a striped aspect.

Geology. A science which has for its object to investigate the structure of the earth, the materials of which it is composed, the manner in which these are arranged, with regard to each other; and it considers the action of all natural causes in producing changes, such as the effects of frost, rain, floods, tides, currents, winds, earthquakes and volcanos.

Economical Geology refers to the applications of geological facts and observations to the useful purposes of civilized life.

Granite. An unstratified rock, composed generally of quartz, feldspar and mica, and it is usually associated with the oldest of the stratified rocks.

Graywacke Grauwacke. A group of strata in the transition of rocks; but the term has been so indefinitely applied, that other names will probably be substituted.

Greenstone. A trap rock, composed of hornblend and feldspar.

Grit. A coarse-grained sandstone.

Gypsum. A mineral, composed of sulphuric acid and lime, and extensively used as a stimulant manure, and for making stucco and plaster casts, &c. It is also called Plaster of Paris.

Hornblende. A mineral of a dark green or black color, and which is a constituent part of greenstone.

Hornstone. A siliceous mineral, approaching to flint in its characters.

In Situ. In their original position where they were formed.

Laminae. The thin layers into which strata are divided, but to which they are not always parallel.

Lacustrine. Belonging to a lake. Depositions formed in ancient as well as modern lakes, are called lacustrine deposits.

Landslip. It is the removal of a portion of land down an inclined surface. It is in consequence of the presence of water beneath, which either washes away the support of the superincumbent mass, or so saturates the materials that they become a slippery paste.

Line of Bearing, is the direction of the intersection of the planes of the strata with the plane of the horizon.

Lignite. Wood naturally carbonized and converted into a kind of coal in the earth.

Littoral. Belonging to the shore,

Loam. A mixture of sand and clay.

Mural Escarpment. A Rocky cliff with a face nearly vertical like a wall.

Mammillary. A surface studded with smooth small segments of spheres like the swell of the breasts.

Mammoth. An extinct species of the elephant.

Marl. By this term an argillaceous carbonate of lime is usually implied. By custom, its signification is much more extended, and means mineral substances, which act as stimulating or fertilizing manures. There are clay marls, shell marls, and various others.

Mastodon. A genus of extinct fossil animals allied to the elephant. They are so called from the form of the grinders which have their surfaces covered with conical mammillary crests.

Matrix. The mineral mass in which a simple mineral is imbedded, is called its *matrix* or *gangue.*

Megatherium. A fossil extinct; quadruped resembling a gigantic sloth.

Mechanical origin Rocks of, Rocks composed of sand, pebbles or fragments, are so called, to distinguish them from those of a uniform crystalline texture, which are of chemical origin.

Mica. A simple mineral having a shining silvery surface, and capable

of being split into very thin elastic leaves or scales. The brilliant scales in granite and gneiss are mica.

Mica Slate. One of the stratified rocks belonging to the primary class. It is generally fissile, and is characterized by being composed of mica and quartz, of which the former either predominates, or is disposed in layers, so that its flat surfaces give it the appearance of predominating.

Miocene. One of the deposits of the tertiary epoch. It is more recent than the *eocene*, and older than the pliocene.

Mollusca. Molluscous animals. "Animals, such as shell fish, which, being devoid of bones, have soft bodies."

Mountain Lmestone. "A series of limestone strata, of which the geological position is immediately below the coal measures, and with which they also sometimes alternate."

Muriate of Soda. Common Salt.

Naphtha. A fluid volatile inflamable mineral, which is common in volcanic districts, and in the vicinity of the Salt Springs of the United States.

New Red Sand-stone. "A series of sandy and argillaceous, and often calcareous strata, the prevailing color of which is brick red, but containing portions which are greenish grey. These occur often in spots and stripes, so that the series has sometimes been called, the variegated sandstone. The European, so called, lies in a geological position immediately above the coal measures."

Nodule. A rounded, irregular shaped lump or mass.

Old Red Sand-stone. "A stratified rock, belonging to the carboniferous group of Europe."

Oolite. "A lime-stone, so named, because it is composed of rounded particles like the roe or eggs of fish. The name is also applied to a large group of strata characterized by peculiar fossils."

Organic Remains. See *Fossils.*

Orthoceratite. The remains of an extinct genus of molluscous animals, called Cephalopoda. The orthoceratites are long, straight, conical chambered shells.

Out-crop. See *Crop-out.*

Out-liers. Hills or ranges of rock strata, occurring at some distance from the general mass of the formations to which they belong. Many of these have been caused by denudation, having removed parts of the strata which once connected the out-liers with the main mass of the formation.

Oxide. A combination of oxygen with another body. The term is usually limited to such combinations as do not present active acid or alkiline properties.

Palaeontology. A science which treats of fossil remains.

Pisolite. A calcareous mineral, composed of rounded concretions like peas.

Pliocene. The upper, or more recent tertiary strata. This group of strata is divided into the older and newer pliocene rocks.

Petroleum. A liquid mineral pitch. It is common in the region of salt springs in the United States.

Porphyry. A term applied to every species of unstratified rock, in which detached crystals of feldspar are diffused through a compact base of other mineral composition.

Productus. An extinct genus of fossil bivalve shells.

Plastic Clay. One of the beds of the Eocene period. The plastic clay formation is mostly composed of sands with associate beds of clay.

Pudding Stone. See *Conglomerate.*

Pyrites. A mineral, composed of sulphur and iron. It is usually of a brass yellow, brilliant, often crystalized, and frequently mistaken for gold.

Quartz. A simple mineral, composed of silex. Rock crystal is an example of this mineral.

Rock. All mineral beds, whether of sand, clay, or firmly aggregated masses, are called rocks.

Sand-stone. A rock composed of aggregated grains of sand.

Saurians. Animals belonging to the lizard tribe.

Schist. Slate.

Seams. "Thin layers which separate strata of greater magnitude."

Secondary Strata. "An extensive series of the stratified rocks, which compose the crust of the globe, with certain characters in common, which distinguish them from another series below them, called primary, and another above them, called tertiary."

Sedimentary Rocks—Are those which have been formed by their materials having been thrown down from a state of suspension or solution in water.

Selenite. Crystalized gypsum.

Septaria. Flattened balls of stone, which have been more or less cracked in different directions, and cemented together by mineral matter which fills the fissures.

Serpentine. A rock composed principally of hydrated silicate of magnesia. It is generally an unstratified rock.

Shale. An indurated slaty clay, which is very fissile.

Shell Marl—Fresh water Shell Marl. A deposit of fresh water shells, which have disintegrated into a grey or white pulverulent mass.

Shingle. The loose, water-worn gravel and pebbles on shores and coasts.

Silex. The name of one of the pure earths which is the base of flint, quartz, and most sands and sand-stones.

Silt. "The more comminuted sand, clay and earth, which is transported by running water."

Simple Minerals—Are composed of a single mineral substance. Rocks are generally aggregates of several simple minerals cemented together.

Slate. A rock dividing into thin layers.

Stalactite. Concreted carbonate of lime, hanging from the roofs of caves, and like icicles in form.

Stalagmites. Crusts and irregular shaped masses of concreted carbonate of lime, formed on the floors of caves, by deposits from the dripping of water.

Stratification. An arrangement of rocks in strata.

Strata. Layers of rock parallel to each other.

Stratum. A layer of rocks; one of the strata.

Strike. The direction in which the edges of strata crop out. It is synonimous with *line of bearing.*

Syenite and *Sienite.* A granitic rock, in which hornblende replaces the mica.

Synclinal line and *Synclinal axis.* When the strata dip downward in opposite directions, like the sides of a gutter.

Talus. In geology, a sloping heap of broken rocks and stones at the foot of many cliffs.

Tertiary Strata. "A series of sedimentary rocks, with characters which distinguish them from two other great series of strata—the secondary and primary—which lie beneath them."

Testacea. "Molluscous animals, having a shelly covering."
Tepid. Warm.
Thermal. Hot.
Thin out. Strata which diminish in thickness until they disappear, are said to *thin out.*
Trap—Trappean Rocks. Ancient volcanic rocks, composed of feldspar, hornblende and augite. Basalt, greenstone, amygdaloid and dolerite, are trap rocks.
Travertin. "A concretionary lime-stone, hard and semi-crystalline, deposited from the water of springs."
Tufa Calcareous. "A porous rock, deposited by calcareous waters on exposure to air, and usually containing portions of plants and other organic substances incrusted with carbonate of lime."
Tufaceous. A texture of rock like that of tuff.
Tuff or *Tufa.* "An Italian name for a volcanic rock of an earthy texture."
Unconformable. See conformable.
Veins. Cracks and fissures in rocks filled with stony or metallic matter. Most of the ores are obtained from metallic veins.
Zoophytes. Coral sponges and other aquatic animals allied to them.

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